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THE
BOTANICAL GAZETTE

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ERRATA.

P. 64, line 10, for TAXONIC read TAXONOMIC.

P. 71, line 18, for alga read algal.

P. 90, line 2 from bottom, for BURRIDGE read BURRAGE.

P. 298, line 14, for plolen read pollen.

P. 303, last line, for von read van.

P. 387, line 13, after find insert this.

P. 394, line 4, for Bloomsberry read Bloomsbury.

VOLUME XXIII NUMBER 1

BOTANICAL GAZETTE

JANUARY 1897

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XVII.

JOHN DONNELL SMITH.

(WITH PLATE I)

THIS paper includes some new species, detected in the series of Costa Rican plants collected by Professor Pittier and his assistant employees of the National Herbarium of Costa Rica. Mr. E. W. Nelson's collections in Guatemala, submitted to me by the Smithsonian Institution for determination, have also furnished several novelties.

Guatteria oliviformis Donnell Smith.— Folia subtus praesertim ad nervos pubescentia oblongo-elliptica et utrinque acuta aut e basi obtusa elliptica et cuspidata. Pedunculi axillares solitarii crassi floris parvi diametrum subaequantes supra basin articulati et pluri-bracteolati. Petala cano-velutina subaequalia orbiculari-ovata. Baccae circiter 20 magnae ellipticae stipitibus crassis altero tanto longiores.

A small tree. Pubescence ferruginous. Leaves shortly petiolate, coriaceous, glabrous above except midrib, 4–7 × 1¾–2 in. Peduncules 9–11 l. long; bracteoles present only in the bud, 4–5, amplexicaul. Sepals orbicular, acuminate, 2 l. long, glabrous within. Petals obtuse, 4–5 l. long, thickened externally at base with a sericeous triangle. Stipes pubescent at angles and little longer than ovary, stigmas pubescent, facets of torus pilose. Berries 9 × 5 l., each end obtuse.

Rio Segundo, Volcán de Barba, Costa Rica, alt. 6000 ft., Jan. 1890, Tonduz, no. 1740 herb. nat. C. R.—Páramos del Abejonal, C. R., alt. 5700 ft., Apr. 1893, Tonduz, no. 7802 herb. nat. C. R.

Guatteria dolichopoda Donnell Smith.—Folia lanceolato-oblonga longe acuteque acuminata deorsum cuneata. Pedunculi axillares solitarii graciles floris viridis sericei diametrum aequantes et in primi trientis articulatione et in basi bracteolati. Petala extus ad basin versus ochroleuco-sericea parum inaequalia obtusa, exteriora oblonga, interiora oblongo-ovata excrescendo oblongata intus ad basin versus glabra sepalis ter quaterve longiora. Stipites filiformes baccas ovales numerosissimas 3–4-plo superantes.

Tree 20 ft. high with reclinate branches and a dusky patent pubescence. Leaves chartaceous, pilose, at length glabrescent, paler beneath, 5–7 × 1 ½–2 in. Buds yellow-sericeous. Peduncles 1 ¼–1 ¾ in. long; bracteoles oblong-ovate, 2 l. long, caducous. Sepals ovate, acuminate, 2 ½ l. long, glabrous within. Exterior petals sericeous throughout, 9×3 l., the interior 10×4–5 l. Ovaries shorter than the sericeous stipes; torus hemispherical, excavate. Berries 30–50, green, glabrous, obtuse at each end, 4×3 l.; stipes red, glabrous, 11–16 l. long, chiefly equaling the upper article of peduncle, torus 4 l. broad.—To be located with *G. nigrescens* Mart.

Shirores, Talamanca, Costa Rica, alt. 300 ft., Feb. 1895, Pittier & Tonduz, no. 9166 herb. nat. C. R.—La Concepión, Llanos de S. Clara, C. R., alt. 700 ft., Feb. 1896. Donn. Sm., no. 6429 Pl. Guat., etc., qu. ed. Donn. Sm.

Asimina Costaricensis Donnell Smith.—Glaberrima. Folia membranacea elliptico-oblonga abrupte longeque acuminata, summo apice obtuso, basi acuta, nervis lateralibus utrinque 7–8 tenuibus. Pedunculi laterales elongati, toro depresso-globoso nodoso, baccis circiter 8 oblongis pedunculum aequantibus breviter stipitatis, seminibus circiter 14 biserialibus.

Leaves 6–8 × 1 ¾–2 ¾ in., petioles 3–4 l. long. Peduncles remote from axil, 1 ¾ in. long, thickened upwards, recurved. Torus 5 l. in diameter, stipes 5 l. long; berries 24 × 10 l., fleshy, smooth and shining; seeds oblong, 7 × 4 l., obtuse at each end, vertically slightly compressed, pale yellow, incompletely enclosed by membranaceous ruptured arillus.

Sipurio, Talamanca, Costa Rica, alt. 600 ft., Apr. 1894, Tonduz, no. 8709 herb. nat. C. R.

Capparis filipes Donnell Smith. (Subgen. BREYNIASTRUM DC.)—Lepidota. Folia brevissime petiolata paene pedalia oblongo-obovata abrupte longeque acuminata ad basin acuta, juniora utrinque adulta subtus argenteo-lepidota. Pedunculi filiformes, pedicellis gracilibus singulis aut usque ad 6 umbellatim confertis. Petala ovalia sepalis 5-plo longiora a staminibus dimidio a gynophoro bis superata.

Scales stellate; those of branchlets, petioles, inflorescence and flowers ferruginous. Leaves 6–11×2¾–3¾ in., caudate apex ½–1½ in. long, petioles 2–4 l. long. Peduncle terminating short axillary branches, 2½–3½ in. long, pedicels 10 l. long. Sepals triangular, 1 l. long, twice exceeding scales of disk. Petals cano-tomentose sprinkled with scales. Stamens about 20. Ovary cano-tomentose, 2 l. long; gynophore glabrous, 10 l. long. Berry not seen.—A most distinct species in the subgenus by the large leaves and the slender axes of inflorescence.

Suerre, Llanos de S. Clara, Costa Rica, alt. 900 ft., Apr. 1896, Donn. Sm., no. 6433 Pl. Guat., etc., qu. ed. Donn. Sm.—Santa Clara, C. R., Sept. 1896, Cooper, no. 10,238 herb. nat. C. R.

Trigonia thyrsifera Donnell Smith. (§ CYMOSAE Warm.)—Folia discoloria supra glabrescentia subtus niveo-tomentulosa elliptico- vel obovato-oblonga utrinque acuta, costis petiolisque sicut inflorescentia fuscis. Paniculae axes primarii pauci oppositi erecti elongati thyrsoidei, secundarii breves crebri cymas ter quaterve dichotomas subaequantes, floribus minimis. Sepala extus nivea intus glabra.

Arborescent (Biolley), branchlets quadrangular. Leaves somewhat bullate, 4½–6×1¾–2¼ in., base and apex slightly conduplicate, nerves 8–9 to the side. Petioles ½ in. long. Panicle contracted, nearly a foot long, branches in about two pairs, 6–7 in. long; bracts foliaceous, elliptical, 2×¾ in., each end rounded. Peduncles 5 l. long; bractlets ¾–1½ l. long, triangular-lanceolate, incurved, canescent; flowers crowded, pedicels ½–1 l. long. Sepals 1½–2 l. long. Petals white (Biolley), 1½–2 l. long; the spur globose, 1 l. long, equaling the orbicular-obovate blade. Perfect stamens 6. Glands 2, transversely oblong, crenate. Ovary sericeous, ovate. Capsule not seen.

Llanos de Surubres, Prov. Alajuela, Costa Rica, alt. 600 ft., July 1890. Biolley, no. 2638 herb. nat. C. R.

Waltheria rhombifolia Donnell Smith.—Arborea, ramulis petiolisque tomentosis. Folia dentata rugosa supra scabrida subtus cano-velutina obovato- vel ovali-rhomboidalia acuta, inferiora magis ovalia, ad basin rotundam 3–5-nervia. Glomeruli axillares sessiles maximi cano-sericei, bracteis obtusis, lateralibus spatulatis, mediana obovata 2–3-lobata. Petala anguste spatulata calycem staminaque aequantia, antheris sessilibus.

Indument glandular-punctate. Stipules subulate, 3 l. long. Leaves 3–5¼ × 1½–2½ in., the younger cano-velutinous on both sides, nerves above base 6–7 to the side, petioles 3–5 l. long. Glomerules of condensed cymes capituliform, at length an inch in diam. Calyx cano-sericeous, subequaling bracts, 2¼ l. long; teeth triangular, ¼ l. long. Filaments completely united in a tube, thrice longer than the linear anthers. Ovary villose, style pubescent, shortly exsert, stigma globose. Seed obovoid, not compressed, glabrous.—*W. glomerata* Presl. appears to be the most nearly related species and differs chiefly by leaves and nearly free filaments.

Rio Ceibo, Costa Rica, alt. 750 ft., Feb. 1891, Tonduz, no. 4038 herb. nat. C. R.—Boruca, C. R., Nov. 1891, Pittier, no. 4574 herb. nat. C. R.—Buenos Ayres, C. R., alt. 900 ft., Jan. 1892, Tonduz, no. 6696 herb. nat. C. R.—Mozote de Caballo, C. R., Jan. 1892, Pittier, no. 7061 herb. nat. C. R.

Zanthoxylum procerum Donnell Smith. (§ TOBINIA Desv.; Triana et Planch.)—Arbor excelsa aculeata glabra. Folia maxima 2–6-juga abrupte pinnata, foliolis oblongo- vel obovato-ellipticis, apice acuminato, basi attenuata, margine leviter crenulato glandaligero. Corymbi terminales ampli decompositi, floribus minimis dioicis. Sepala semiorbicularia petalis ellipticis 3-plo breviora. Ovarium monogynum.

Tree 40–50 ft. high. Spines conical. Common petiole prickly beneath, 8–14 in. long. Leaflets coriaceous, shining, midrib and nerves prominent beneath, shortly petiolulate, the upper 5½–6¾ × 1¾–2 in., the lower smaller and less elongated. Axes of corymb canaliculate by decurrent triangular bracteoles. Flowers crowded, ¾ l. long, exceeding pedicels. Petals imbricate, obtuse, concave. Of masculine flowers stamens exserted; rudimentary ovary sessile, conical. Of feminine flowers squamules none; ovary globose, punctate, shorter than style, twice longer than gynophore. Fruit not seen.—Nearest to *Z. Pringlei* Watson.

S. Mariá de Dota, Comarca de Punta Arenas, Costa Rica, alt. 3900 ft., Apr. 1890, Tonduz, no. 2348 herb. nat. C. R.—S. Domingo, Golfo Dulce, C. R., Apr. 1896, Tonduz, no. 9920 herb. nat. C. R.—La Emilia, Llanos de S. Clara, C. R., alt. 700 ft., May 1896, Donn. Sm., no. 6469 Pl. Guat., etc., qu. ed. Donn. Sm.

Colubrina spinosa Donnell Smith.—Spinis axillaribus armata. Folia glabrescentia integra penninervia ovalia, apice obtuse acuminato, basi biglandulari cuneata vel rotunda. Pedunculi pluri-fasciculati graciles. Petala calycis dentes vix aequantia. Discus crenatus. Drupa magna ecostata pallida, coccis bivalvibus, seminibus orbicularibus rubescentibus punctulatis.

Buds, petioles, peduncles and calyx ferruginous-pubescent. Spines slender, 6–8 l. long. Leaves 3½–5½ × 1¾–2½ in., nerves prominent beneath and about eight to the side. Peduncles bracteose at base, about 7 l. long, subequaling petioles. Calyx 1 l. high. Petals oval. Drupe globose, thrice exceeding its cupule, 4¼ l. in diam., dehiscing to the middle septicidally from the base and loculicidally from the apex. Seeds glaucous, convex on one side, plane and slightly angled on the other, 3 l. in diam., cotyledons bright green.

Forests of Boruca, Costa Rica, Nov. 1891, Tonduz, no. 4569 herb. nat. C. R.—Rio Zhorquin, C. R., March 1894, Tonduz, no. 8507 herb. nat. C. R.

Mauria glauca Donnell Smith.—Glaberrima, ramulis petilis costis paniculis glaucis. Folia 3–4-juga saepe abrupte pinnata, foliolis superne olivaceis et lucidis lanceolatis vel oblongo-ellipticis, apice acuto, basi inaequali cuneata. Paniculae axillares et terminales saepissime binae foliis breviores, ramis laxis patulis, inferioribus elongatis.

Tree 20 ft. high with a rounded summit. General petiole 4–6 in. long. Leaflets 4–5 × 1–1¾ in., usually slenderly elongated, margin subundulate, flat midrib and lateral nerves pellucid, the latter numerous and joining only in a marginal nerve. Petiolules 1–2 l. long. Panicles 4–5 in. long; branches few, complanate, loosely flowered, the lowest 2–3 in. long; bracteoles minute, triangular, sometimes pubescent; flowers globose and rubescent in the bud, hermaphrodite. Sepals glabrous, minutely and broadly triangular. Petals pale yellow, oblong-ovate, 1½ l. long, somewhat exceeding stamens. Ovary oblong-ovate, stigmas three and sessile. Immature berry obliquely oval, 4 l. long.—Differing little from *M. Biringo* Tul. except by leaves and inflorescence.

Tres Rios, Costa Rica, March 1887, Pittier, no. 88 herb. nat. C. R.—Rio Ciruelas, C. R., March 1890, Biolley, no. 2229 herb. nat. C. R.—Rio Torres, Prov. S. José, C. R., alt. 3300 ft., Jan. 1896, Tonduz, no. 9848 herb. nat. C. R.—S. José, C. R., alt. 3400 ft., February 1896, Donn. Sm., no. 6461 Pl. Guat., etc., qu. ed. Donn Sm.

Rourea Suerrensis Donnell Smith.—Foliola 3–5 maxima nitida elliptico- vel obovato-oblonga cuspidata ad basin acuta vel obtusa penninervia transversim venosa. Paniculae terminales et ex axillis supremis ortae laxae petiolos subaequantes, floribus majusculis, pedicellis brevibus. Sepala praeter margines glabra rotundo-ovata tubum multoties excedentia petalis oblongis dimidio breviora, fructigera tubum aequantia capsulae quartam partem amplectantia.

A small tree. Leaves chartaceous, with petiole 2–4 in. long added, 10–15 in. long; terminal leaflet 7–9 × 2¾–4 in., petiolule 1¼–1½ in. long; lower leaflets often alternate, elliptical, 3½ × 1¾ in., base obtuse; nerves 5–7 to the side. Calyx in anthesis equaling pedicels, 1½ l. high. Petals 2½ × 1 l., obtuse at each end. The shorter stamens as long as sepals. Carpels pilose, lanceolate, at length much exceeded by styles. Capsule glabrous, 6 × 3 l. Cupuliform yellow aril embracing a fourth of the seed.

Suerre, Llanos de S. Clara, Costa Rica, alt. 900 ft., Feb. 1896, Donn. Sm. no. 6466 Pl. Guat., etc., qu. ed. Donn. Sm.

Cassia Guatemalensis Donnell Smith. (§ CHAMAESENNA DC. Ser. *Pachycarpæ* Benth.)—Folia 4–8-juga, jugis 2 inferioribus glandula intrapetiolulari instructis, foliolis oblongis utrinque rotundis vel ad imam basin cuneatis, costis marginibusque pilosis. Petala inter minora sepalis parum longiora. Antherarum perfectarum poro duplici apiculatarum 3 ceteris longiores. Leguminis lineari-oblongi valvulae planae, semina obliqua obovoidea.

Fruticose, except leaf surfaces pubescent. Fully grown leaves nearly a foot long; leaflets chiefly in 6–8 pairs, 1½–2 in. × 6–10 l., decreasing below and more oval, apex mucronulate or retuse, base chiefly rounded, veiny, margins scarious. Stipules linear, 3 l. long. Bracts linear, 4 l. long, present only in undeveloped peduncles. Racemes axillary, subequaling leaves, long-pedunculate, many-flowered. Pedicels subequaling flowers, in fruit 7–9 l. long. Sepals pubescent, suborbicular, the interior 3 l. and the exterior 2 l. long. Petals obovate, 4–3 l., unguiculate, venose. Anthers smooth, incurved, equaling filaments, the longer 3 l. and the shorter 1¼ l. long; lamina of staminodes oblong. Ovary flavo-sericeous. Pod smooth, flat, slightly curved, 3½ in. × 6 l., apex obtuse, base cuneate, shortly stipitate, margins nerviform, dehiscing at each suture. Seeds 8–9, slightly compressed parallel with valves, 4×2½ l.—Nearest perhaps to *C. Botteriana* Benth. The doubt, expressed by M. Micheli (Donn. Sm. Enum. Pl. Guat., etc., 4:45) in referring the Santa Rosa specimen (with flowers only) to *C. corymbosa* Lam., is confirmed by Mr. Nelson's more complete specimens with pods that require the assignment of the plant to a different section of the genus.

Buena Vista, Depart. Santa Rosa, Guat., alt. 5500 ft., Dec. 1892, Heyde & Lux, no. 4176 Pl. Guat., etc., qu. ed. Donn. Sm. Between San Martin and Todos Santos, Depart. Huehuetenango, Guat. alt. 7000–8500 ft., Dec. 1895, E. W. Nelson, no. 3626.

Alchemilla ocreata Donnell Smith.— Palmaris, caulibus decumbentibus ramosis flavo-sericeis. Folia ocreis amplexicaulia arcte imbricata, laciniis 6–8 lanceolatis vaginam superantibus. Flores terminales pluri-glomerati diandri octogyni.

Cespitous, branching from the base upwards. Segments of leaves 2 l. long, concealing the sheaths, margins revolute. Calyx campanulate, 1¼ l. high, dentate nearly to the middle; teeth 8–10, subequal, acute, the exterior lanceolate, the interior ovate. Stamens opposite, occasionally 3. Carpels stipitate, style basilar. Achenia pale, cotyledons orbicular.— *A. nivalis* H. B. et K. (no. 4205 Triana!), the only related species, differs by habit, grayish indument, numerous and narrow leaf-segments, 4-carpellate ovary.

Thickets at General, Comarca de Punta Arenas, Costa Rica, alt. 1800 ft., Jan. 1891, Pittier, no. 3431 herb. nat. C. R.

COMBRETUM FARINOSUM H. B. et K., var. **phaenopetala** Donnell Smith.— Folia subtus lepidibus rubro-punctata. Spicae pubentes cum calycibus et samaris rufo-lepidotae. Petala rotundo-ovalia lobis calycis turbinato-campanulati non satis breviora, disci margine tantum ciliato, antheris minimis.

Near Neuton, Depart. Huehuetenango, Guat., alt. 3000–4000 ft., Dec. 1895, E. W. Nelson, no. 3534.

Loasa bipinnata Donnell Smith.— Tota urenti-setosa et scabrida. Folia triangularia pinnata superne pinnatifida, foliolis utrinque 2–3 petiolulatis oblongo-ellipticis pinnatim lobatis incisis, segmentis infimis sejunctis. Petala ad apicem bifida calycis lobis ovatis bis longiora. Squamae lobulis duobus appositis apiculatae. Staminodia lineari-oblonga aristulata.

Leaves alternate, paler and more sparsely setose beneath, 4–6 in. long; leaflets chiefly opposite, 3–4 × 1–1½ in., those of lower leaves pinnatifid and at base pinnate. Petioles 1¼–2 in. long. Peduncles extra-axillary, short, 1-flowered, in fruit ¾–1¼ in. long. Calyx-lobes acute, 3 l. long. Petals 5–6 l. long, scabrid, sparsely setose, lanceolate, cymbiform, unguiculate, tipped with two slender teeth. Nectariferous scales oblong-ovate, 2 l. long. Anthers didymous. Staminodes 2¼ l., the awn ¾ l. long. Capsule obconic, 7 l. long.— This may be presumed to be the *Loasa* sp. n. 3 from Guatemala and Costa Rica, cited by Mr. Hemsley as nearest to *L. chelildonifolia* Benth.

Desamparados, Prov. S. José, Costa Rica, alt. 3400 ft., Sept. 1889, Pittier, no. 1314 herb. nat. C. R.— Llanos de Alajuelita, Prov. S. José, C. R., alt. 3200 ft., Dec. 1889, Tonduz, no. 1477 herb. nat. C. R.

Loasa speciosa Donnell Smith.—Setis urentibus horrida. Folia inferiora opposita, subtus praeter nervos esetosa et venis aureo-pubescentibus pulchre reticulata, palmatim 5-fida ad basin cordatam 5-nervia, segmentis triangularibus acute lobatis, terminali maximo. Flores hujus generis maximi. Squamae laciniis calycinis dimidio breviores in apice bifido lobulis 2 intermediis instructae, ad basin plica bilobata appendiculatae.

A large herbaceous plant with leaves 4–5 in. long and broad, and petioles one-half or fully as long. Peduncles axillary, 2–3 in. long, 1-flowered. Flowers 5 in. in diam. Calyx-segments elongate-lanceolate, 1½ in. long, 3-nerved. Petals nearly plane, externally setose and pubescent, oblong-oval, 2¼ × 1 in. Nectariferous scales oblong, 8 × 3 l., exterior lobes 2 l. long, the interior oblong and a half shorter, basal appendages semi-orbicular. Anthers oblong. Staminodes filiform, a half longer than the scales, barbate. Capsules not seen.—Nearest to *L. argemonoides* Humb. et Bonpl.

Forests of Volcán Turrialba, Prov. Cartago, Costa Rica, alt. 7500 ft., Jan. 1889, Pittier. no. 875 herb. nat. C. R.—Same locality, Mch. 1894, F. N. Cox, no. 4812 Pl. Guat., etc., qu. ed. Donn. Sm.

Diplostephium corymbosum Donnell Smith.—Pubescens. Folia elliptico-oblonga acuta ad basin rotundata, marginis subrevoluti crenaturis mucronatis. Corymbi polycephali. Involucri hirtelli a disco superati bracteae lineari-lanceolatae. Flores feminini plerumque 1–interdum pluri-seriati, ligulis violaceis patentibus cum tubo aequilongis discum superantibus. Stylorum disci rami oblongi. Achaenia pubescentia, setis plerisque elongatis aequalibus rubescentibus, paucis brevibus intermixtis.

Shrub 2–3 ft. high. Leaves 2¼–4 × ¾–1½ in., strigillose above, velutinous beneath, faintly crenulate. Petioles hirsute, 4–8 l. long. Corymbs obpyramidal, 3–4 in. wide. Heads 3 l. high. Scales of obconic involucre about 4-seriate with acute colored tips. Ligules oblong-elliptical, 1¼ l. long, 3-denticulate. Disk-flowers few or numerous.

Todos Santos, alt. 10,000 ft., Dec. 1895, no. 3639, Hacienda de Chancol, alt. 11,000 ft., Jan. 1896, no. 3644. Depart. Huehuetenango, Guat., E. W. Nelson.

Diplostephium paniculatum Donnell Smith.—Praeter faciem superiorem foliorum et capitula totum cano-floccosum. Folia discoloria lanceolato-ovata ad imam basin cuneata, margine revoluto et grandidentato. Panicula ampla pyramidalis decom-

posita. Involucri glabri discum aequantis bracteae lineares. Flores feminini pluri-seriati, ligulis suberectis minimis tubo 3-plo brevioribus discum vix ac ne vix quidem superantibus. Flores disci pauci, stylorum ramis ellipticis. Achaenia glabra, setis plerisque elongatis aequalibusque, paucis minimis intermixtis.

Leaves 3¼–5 × 1½–2 in., sharply and mucronately dentate, acute tip entire, green and scabrid above. Panicle 5–7 in. high and as wide at base, axes spreading, the primary ones bracteated by reduced leaves. Heads subequaling pedicels, 2 l. high. Scales of obconic involucre 3-seriate, narrow, obtuse, lacerate. Ligules obovoid, ⅓ l. long, 3-denticulate. Disk-flowers about 4.—The inflorescence is exceptional, as is also the habit of this and the preceding allied species.

Between San Martin and Todos Santos, Depart. Huehuetenango, Guat. alt. 7000–8500 ft., Dec. 1895, E. W. Nelson, no. 3629.

VERBESINA FRASERI Hemsl., var. **Nelsoni** Donnell Smith.—Folia saepius lobata. Capitula minora plerumque 3-aggregata, involucri bracteis 3-seriatis, serium exteriorum bracteis 1–1½-linealibus ovatis crassis adpressis, receptaculi bracteis post lapsum florum in apice lutescentibus. Forsitan species distincta.

Near Neuton, Depart. Huehuetenango, Guat., alt. 3000–4000 ft., Dec. 1895, E. W. Nelson, no. 3551.

Calea Guatemalensis Donnell Smith.—Glaberrima. Nodi exappendiculati. Folia oblongo-elliptica utrinque consimiliter angustata integerrima. Corymbus terminalis amplus polycephalus inferne 3- superne 2-chotomus, bracteis foliaceis sessilibus, pedicellis gracilibus. Involucri hemispherici bracteae 2-seriatae bracteis receptaculi conici breviores. Limbus corollarum tubulosarum tubo paene bis longior exsertus, tubus et ligulatarum et tubulosarum paleas 4 achaenii tetragoni aequans.

Branches terete, uppermost internodes 2 in. long, the leaves 4–6 × 1½–2¼ in., the petioles ¾ in. long. Corymb obpyramidal, 5–9 in. wide, bractlets reduced gradually upwards, pedicels an inch or more long with scattered bractlets. Heads ⅓ in. high and wide. Involucral bracts oblong-ovate, the interior 1½ l. long. Bracts of receptacle oblong, 2 × ¾ l., nearly flat, membranaceous, obtuse apex erose. Ray-flowers about 8, ligule oblong-elliptical, 4 × 1½ l., 4-veined, entire. Disk-flowers numerous, 3 l. long. Achenia oblong, attenuate below, angles ciliolate; palets of pappus triangular-linear, 1 l. long, hyaline, lacerate.—*C. manicata* Benth. et Hook., nearly related, differs chiefly by interpetiolar appendages, lanceolate and denticulate leaves, smaller heads, less exserted disk-flowers with tube exceeding the limb and the palets of pappus.

Between San Martín and Todos Santos, Depart. Huehuetenango, Guat., alt. 7,000–8,500 ft., Dec. 1895, E. W. Nelson, no. 3624.

Buddleia megalocephala Donnell Smith.—Lana flavescente induta. Folia longe petiolata integra supra nitida elongato-lanceolata ad basin angustam obtusa. Capitula magna sphaerica longe pedunculata in racemum terminalem disposita, bracteis subulatis, floribus conglomeratis, corollae majusculae campanulato-rotatae lobis orbicularibus cum tubo aequilongis.

Indument stellate. Leaves 7½–8½ × 1¾–2 in.; nerves 18–20 to the side, spreading at nearly a right angle, arcuate; petioles stout, 1–1¼ in. long. Raceme 6–7 in. long; peduncles stout, in 5–6 pairs, the lowest 1¾ in. long; bracts and bracteoles 3–4 l. long, caducous. Heads 7–9 l. in diameter, tomentose. Calyx turbinate, 2 l. high, equaling linear membranaceous bractlets, ⅓-lobate, lobes triangular. Corolla 3 l. high, lobes externally tomentulose. Stamens included, oblong anthers affixed below sinuses. Ovary tomentose, style clavate.—Allied to *B. globosa* Lam.

Mountains near Hacienda de Chancol, Depart. Huehuetenango, Guat., alt. 11,000 ft., Jan. 1896, E. W. Nelson, no. 3640.

Tournefortia Nelsoni Donnell Smith. (§ PITTONIA DC.)—Sordide pubescens. Folia pedalia petiolis ter quaterve longiora supra strigilloso-subtus velutino-pubescentia oblongo-ovata longe acuminata ad basin rotunda vel in ima cuneata. Cymae folia aequantis pedunculi axesque pluries dichotomi, spicae plures elongatae. Calycis segmenta lineari-lanceolata inaequilonga. Corollae tubus calycem subduplo lobos ovatos triplo excedens.

Petioles 2½–3½ in. long. Leaves 10–12 × 4–4½ in.; nerves 10–12 to the side, spreading, anastomosing arcuately at margins. Peduncles 4–6 times furcate. Tube of corolla 3–3½ l. long. Stamens affixed at throat, anthers sessessile and lanceolate. Disk minute. Stigma annular.—Nearest to *T. cymosa* L.

Between San Martín and Todos Santos, Depart. Huehuetenango, Guat., alt. 7000–8500 ft., Dec. 1895, E. W. Nelson, no. 3615.

Ipomoea leucotricha Donnell Smith. (§ PILOSICALYCES Peter in Engl Natuerlich. Pflanzenfam. 68–31)—Tota praeter paginam superiorem foliorum et corollam explanatam argenteo-sericea. Folia discoloria supra sparsim pilosa orbiculari-cordata aucta integra. Pedunculi folia superantes, axibus dichotomis fastigiatis. Sepala minima aequalia oblongo-ovata, apice cornuto recurvo. Corolla canescens bipollicaris supra calycem in tubum campanulatum ampliata usque ad ⅓ lobata. Stigma 2-globosum.

Leaves 2½–4 × 2¼–3¼ in. Petioles 1–1½ in. long. Cymes 3–4 times dichotomous, corymbiform; bracts and bractlets linear-lanceolate, 3 l. long; pedicels 5–9 l. long. Sepals 3 l. long. Corolla crimson, 2–2¼ in. long, at throat 1 in. wide. Stamens not reaching to throat, dilated and barbate below, anthers 2 l. long. Ovary glabrous. Capsule not seen.—Near *I. sericophylla* Meissn. non Peter.

Near Neuton, Depart. Huehuetenango, Guat., alt. 3000–4000 ft., Dec. 1895, E. W. Nelson, no. 3512.

Cestrum dasyanthum Donnell Smith.—Glanduloso-pubens. Folia oblongo-ovata ad basin rotunda, margine subundulato, pseudostipulis ovatis. Thyrsi terminales foliosi, floribus extus tomentulosis plerumque terminalibus et aggregatim subspicatis. Corollae tubuloso-infundibularis tubus calyce poculiformi subobsolete denticulato bis longior lobos ovatos acuminatos 3-plo superans, filamentis paulo ultra medium adnatis edentulis tantum ad basin gibbosam pubescentibus.

Leaves slightly pubescent above, more densely so beneath and especially the nerves, 2¼–4 × 1¼–2 in.,,petioles ½–¾ in. long. Thyrses narrowly pyramidal, 3–5 in. long; axes bracteated by reduced leaves, 1–2 in. long; terminal flowers 3–5, the lateral 1–2 and pedicellate; bractlets lanceolate, stipitate, 3 l. long. Calyx 3 × 2 l. Corolla yellow; tube dilating gradually from base, 7 l. long, at throat 2½ l. wide, glabrous within; lobes castaneous, 2½ l. long, plicate. To be located among the species numbered 16–43 of DC. Prodromus.

Between San Martín and Todos Santos Depart. Huehuetenango, Guat., alt. 7000–8500 ft., Dec. 1895, E. W. Nelson, no. 3622.

MERINTHOPODIUM Donnell Smith, nov. gen. SOLANACEARUM.—Calyx herbaceus, segmentis 5 valvatis erectis oblongo-lanceolatis paene sejunctis, nonnullis saepe connatis. Corolla tubuloso-campanulata sensim ampliata 15-nervia, lobis imbricatis erectis oblongo-ovatis, sinubus plicatis. Stamina subinclusa infimo tubo inserta, filamentis filiformibus, antheris magnis, loculis parallelis longitudinaliter dehiscentibus. Discus nullus. Ovarium 2-loculare multiovulatum; stylus filiformis exsertus, lamellis ovalibus ad margines stigmatosis. Bacca ovalis calyce haud aucto cincta, pericarpio membranaceo. Semina pluriseriatim imbricata horizontalia prope basin placentis prominulis affixa ovalia leviter compressa, dorso arcuato, ventre recto; embryo exalbuminosus, cotyledonibus planis orbicularibus subaccumbentibus radicula tereti latioribus paulo brevioribus.—Frutex epiphyticus. Folia glabra integra penninervia. Pedunculi axillares longissimi penduli, apice confertim racemoso-florifero, pedicellis gracilibus, floribus magnis.

Genus inter Cestrineas inflorescentia corolla seminibus distinctum. Nomen pedunculum funiformem indicat.

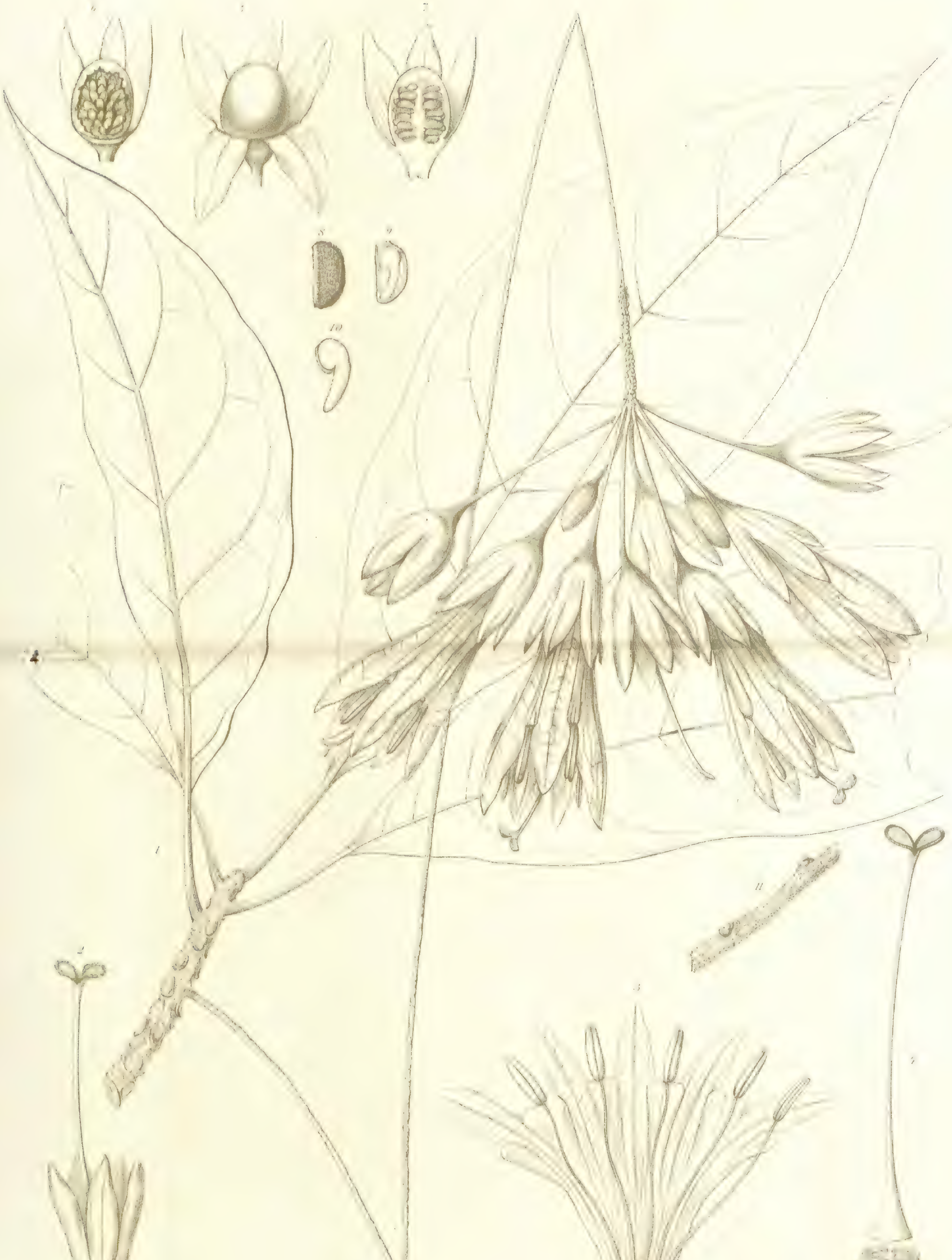
Merinthopodium neuranthum Donnell Smith. (*Markea neurantha* Hemsl. Biol. Centr. Am. Bot. **2**: 429)—Caulis junior cum pedunculis tuberculatus. Folia elliptico- vel obovato-oblonga cuspidata ad basin acuta, nervis lateralibus utrinque 6–8 marginem versus arcuatim conjunctis, venis paene obsoletis. Flores pulverulenti. Corolla calyce bis terve longior usque ad $\frac{1}{5}$–$\frac{1}{4}$ lobata, filamentis inferne pubescentibus, antheris fauces superantibus.

Stems stout, pitted with scars of fallen leaves, tubercles tipped with a hair, epidermis exfoliating. Leaves 5–11 × 2–5 in., petioles $1\frac{1}{4}$–2 in. long. Peduncles filiform, 1–2 ft. long; rhachis 1–2 in. long, often furcate, thickened and densely scarred with articulations of the flowers of former seasons; pedicels subfasciculate 6–13, 1–2 in. long, thickened upwards. Calyx-segments 9–12 l. long, 1-nerved and veiny. Corolla yellowish-green, veiny, very variable in size, $1\frac{1}{2}$–$2\frac{3}{4}$ in. long; lobes oblong-ovate, 4–7 × $2\frac{1}{2}$–5 l., obtuse, sinuses 3–5 l. broad, bilobulate. Anthers 6 l. long. Ovary glabrous, conical; lobes of stigma 2 l. long. Berries 9 × 6 l. Seeds 1 l. long.—In describing this species from imperfect material Mr. Hemsley has suggested that its fruit, when known, might show it to represent a new genus.

La Concepción, Llanos de S. Clara, Costa Rica, alt. 700 ft., Febr. 1896, Donn. Sm., no. 6678 Pl. Guat., etc., qu. ed. Donn. Sm.—Atirro, Prov. Cartago, C. R., alt. 2000 ft., Apr. 1896, Donn. Sm., no. 6679 Pl. Guat., etc., qu. ed. Donn. Sm.—La Palma, Prov. S. José, C. R., alt. 4600 ft., Sept. 1896, Pittier, no. 10,174 herb. nat. C. R.

EXPLANATION OF PLATE I.

Fig. 1, flowering branch.—Fig. 2, calyx.—Fig. 3, corolla laid open. Fig. 4, pistil.—Fig. 5, berry.—Fig. 6, berry with pericarp removed. Fig. 7, vertical section of berry.—Fig. 8, seed.—Fig. 9, vertical section of seed.—Fig. 10, embryo.—Fig. 11, tuberculate twig.



MERINTHOPODIUM NEURANTHUM, Donnell Smith.

Dicliptera sciadephora Donnell Smith.—Folia ovato-lanceolata in petiolum angustata. Pedunculi folia subaequantes simpliciter et nonnunquam composite umbelliferi, pedicellis 3–6 elongatis capitulum biflorum ferentibus, bracteis involucralibus lineari-lanceolatis inaequalibus, floralibus 4 conformibus minoribus, floris tertii abortivi bracteis linearibus. Calycis ultra medium fidi laciniae lineari-triangulares. Antherarum loculi connectivo triangulari sejuncti.

Suffruticose, pubescent. Leaves 2¾–3½ × 1¼–1½ in., lineolate chiefly beneath, penninerved, transversely veined, costa and nerves pubescent, petioles 3–5 l. long. Bracts of umbel 2, filiform, 3 l. long; pedicels chiefly 5, subequal, 1½–2½ in. long. Heads compressed, pubescent; involucral bracts filiform-attenuate, 6–7 l., the floral 4 l. long. Flowers pubescent. Calyx 3½ l. long. Corolla 15 l. long. Capsule pubescent, oblong, 5 l. long, stipitate; seeds 4 or fewer, punctulate; retinacula large, from a broadly dilated base triangular.

Jacaltenango, Depart. Huehuetenango, Guat., alt. 3500–5400 ft., Dec. 1895, E. W. Nelson, no. 3584.

Salvia phaenostemma Donnell Smith.—Glabra. Folia orbiculari-ovata acuminata grosse serrata supra parce puberula. Racemorum elongatorum verticillastri crebri 2–8-flori, pedicellis gracilibus, bracteis parvis linearibus persistentibus. Calyx tubuloso-campanulatus compressus, labiis triangularibus aristulatis, superiori integro, inferioris dentibus connatis. Corollae calyce bis longioris tubus tenuis ad fauces ampliatus, labia inaequalia. Genitalia longissima, filamentis elongatis, connectivis deflexis usque ad medium exsertis.

Leaves 2½–4 × 1¾–3¼ in., petioles 5–14 l. long. Racemes 1–1½ ft. long. Pedicels unequal, 4–7 l. long. Calyx 10-nerved, 5–7 l. long, lips 2 l. long, punctulate within. Corolla blue, glabrous, about an inch long; superior lip oblong-elliptical, 3 l. long, entire; the inferior broader, 2 l. long, lateral lobes minute. Stamens and smooth style overtopping corolla by nearly one half its length; sterile branches of connective dentulate, connate. Appendage of disk small, oval.—To be located with *S. affinis* Cham. et Schlecht. *ex char.*

Between Rodes and Malacate, Depart. San Márcos, Guat., alt. 1400–3500 ft., Jan. 1896, E. W. Nelson, no. 3736.

Salvia monochila Donnell Smith.—Cano-pubens. Folia argute serrulata discoloria ovato-lanceolata ad basin rotunda vel subtruncata. Racemorum verticillastri 2–6-flori, bracteæ foliaceae cum bracteolis ovalibus parvae caducae. Calycis tubuloso-campanulati dentes 3 lati mucronati. Corolla villosa calyce 3-plo longior, labio superiori indiviso, labii inferioris demissi minimi lobis lateralibus reflexis, lobo medio majore patente.

Fruticose. Leaves nearly glabrous above, canescent beneath, 2½–3½ × 1¼–1¾ in., petioles ½–1 in. long. Racemes 5–8 in. long. Calyx about equaling internodes, 6–7 l. long, twice or thrice exceeding pedicels, strongly 7-nerved, glandular, nerves and margins pubescent, interior minutely setulose; teeth 1 l. long, the superior obtuse, the inferior acute. Corolla scarlet, 18–20 l. long, tube nearly cylindrical, superior lip orbicular, 3 l. in diam., the inferior reduced to rounded teeth of limb ½–1 l. high. Stamens equaling corolla; the sterile branch of connective exceeding the fertile one, deflexed, edentulate, connate. Style smooth. Disk unilaterally ovate.—Nearest to *S. nervata* Mart. et Gal. *ex char.*

Todos Santos, Depart. Huehuetenango, Guat., alt. 10,000 ft., Dec. 1895, E. W. Nelson, no. 3635.

Urera Tuerckheimii Donnell Smith.—Rami tuberculati, setis urentibus retrorsis. Folia ovato-lanceolata 3-nervia dentata utrinque praesertim subtus setosa, adulta supra tuberculata. Flores monoici. Cymae petiolis breviores pedunculatae, masculinarum in axilibus superioribus natarum flores 4-meri ad apicem axium glomerati, feminarum repetite dichotomarum flores discreti pedicellati.

Stipules free, lanceolate, 4 l. long, bifid. Leaves 2½–3 in. × 11–13 l., acutely pointed, lateral nerves above base 3–4, petioles 5–7 l. long. Axes of cymes complanate, punctate with cystoliths. Staminate flowers globose, ¾ l. high, rudimentary ovary cupuliform. Pistillate flowers oval, ¼ l. long, ovule elliptical, stigma penicillate; achenia not seen.—Nearest to *U. simplex* Wedd., but distinct in the section by monoicous flowers.

Pansamalá, Depart. Alta Verapaz, Guat., alt. 3800 ft., May 1887, H. von Türckheim, no. 1243 Pl. Guat., etc., qu. ed. Donn. Sm.—Distributed as *Pilea* sp.

BALTIMORE, MD.

MYELOPTERIS TOPEKENSIS, N. SP.

A NEW CARBONIFEROUS PLANT.

D. P. PENHALLOW.

(WITH PLATES II AND III)

DURING the past sixty years a number of plants, variously described under the names of Medullosa[1] (1832), Palmacites[2] (1845), Myeloxylon[3] (1849), Stenzelia[4] (1864), and Myelopteris[5] (1874), have been obtained from the Carboniferous of France, Germany and Great Britain, but, so far as I am aware, no representative of this group has been obtained heretofore from any locality in America.

Recently Professor C. S. Prosser has sent to me three small specimens of flattened stems from the upper Carboniferous of Topeka, Kansas. These fragments are about 6^{cm} long and lie in a matrix of calcite.[6] One specimen represents the full width of the original structure and is 33^{mm} broad. A second has the edges broken off, but a natural extension of the curvatures of the sides shows the probable breadth to have been about 6^{cm}. Both of these specimens have been compressed into a flattened mass having a lenticular transverse section with a maximum thickness of 5^{mm} and 8^{mm} respectively. A third specimen, flattened to an irregularly lenticular mass, represents thin layers of plant residue adherent to the sides of the matrix, and obviously but a small part of the original structure. The dimensions of breadth here given represent very nearly the diameter of the structure in its original form. The general color is that of brown coal. The surface shows occasional areas of thin coaly matter much broken up into small angular fragments, but it is chiefly characterized by a somewhat finely striated appearance due to removal of the cortical layer, with consequent exposure of the underlying strands of sclerenchyma.

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[1] Cotta: Die Dendrolithen in Beziehung auf ihren inneren Bau. Dresden, 1832.

[2] Corda: Beitr. zur Flora der Vorwelt. 1845.

[3] Brongniart: Tab. des gen. de vég. foss. Dict. Univ. d' Hist. nat.

[4] Goeppert: Die foss. Fil. der perm. Form.

[5] Renault: Étude du gen. de Myelopteris. Acad. de Paris **22**:—1875. [no. 10.]

[6] I am much indebted to Dr. B. J. Harrington for determinations of the mineral constituents of these fossils.

The transverse section of the more perfectly preserved specimen shows an outer zone 1.5^{mm} thick, which is continuous on all sides. Central to this and thus forming the axis of the original structure, is a distinctly darker and somewhat more porous mass, containing, here and there, small irregularly rounded masses of pyrite. Upon subsequent microscopical examination, these zonal appearances were found to be due to well defined differences of structure.

The microscopical details present many features of interest and, although the general effects of decay and compression have been to completely destroy the general relations of parts, and in many cases, also, to destroy structural details, these last have been preserved, in some instances, in a remarkably perfect manner.

THE CENTRAL AXIS.—The entire central portion of the stem presents a complete absence of structural detail. The whole central area is occupied by a mass of dark colored material so disposed as to indicate its probable derivation from thin walled tissue, but much altered by decay and the subsequent effects of extreme compression. Here and there, dark colored masses appear, possibly the residue of the mucilage originally present. Throughout this region large rounded openings appear, and while some of these undoubtedly represent the displacement of pyrite, many, and probably all, represent the former locations of vascular bundles. In the dark color and structural character of this area, we find ample reason for its evident separation from the cortical zone, as ascertained upon microscopical examination. Outwardly, this area is limited by a somewhat well defined but narrow and irregular darker line, which is obviously composed of much compressed thin walled cells, but which, nevertheless, seems to suggest a somewhat definite boundary line between a central medulla in which thin walled fundamental tissue predominates, and a somewhat rigid, or at least firmer, outer zone.

THE CORTEX.—No proper cortical structure is represented in these specimens. The outer limits of the sections are defined by more or less broken down strands of sclerenchyma cells, with surrounding parenchyma tissue, making it clear that a certain amount of structure has been removed; and this accords with what has already been noted in specimens of Myelopteris, that "the tissue layers outside the sclerenchyma strands are very rarely preserved."[7] In this case the thin surface layers of coal already described are in all probability to be regarded as representing the cortical structure, which must have been chiefly or wholly parenchymatous in character, and of small radial volume.

THE SUB-CORTICAL LAYER.—The outer, continuous zone, 1.5^{mm} thick as already described, has its macroscopic differentiation from the medulla explained by the large amount of fibrous elements which it contains. Owing to the presence of these elements, and the peculiar way in which they are distributed, they have served not only to protect one another, but they have also served to prevent the effect of compression from falling with full force upon the intervening fundamental structure which in consequence, has often retained its structural features in an exceptionally perfect manner (*figs. 1* and *2*).

PARENCHYMA.—The ground tissue, for the greater part, is much altered by decay and compression, so that all structural features, especially in the central area, have been pretty completely eliminated. Occasionally, however, when protected by earlier infiltration and petrifaction, or by the resisting character of the accompanying strands of hard sclerenchyma, this part of the structure has been preserved in a very beautiful manner (*figs. 1* and *2*). From these areas it is possible to determine the fact that this tissue consists of very variable, but chiefly large and thin walled elements of such a character as to remind me very forcibly of the fundamental structure in many of the larger ferns.

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[7] Solms-Laubach: Foss. Bot. 162.

The intercellular spaces ordinarily met with in such tissue are present, but there is no evidence of the existence of lacunæ.

SCLERENCHYMA.—It has been shown already that the subcortical zone is 1.5^{mm} thick. Within this region there are numerous oval or tangentially elongated bundles of sclerenchyma, which form long strands traversing the stem longitudinally for great distances (*figs. 1, 2*, and *3*). These strands, which give the peculiarly striated appearance to the surface of the specimen wherever exposed, are always separated from one another by several large and thin walled parenchyma cells (*fig. 1*), which are seen to be very perfectly preserved in certain areas. The sclerenchymatous elements are always very thick walled in those strands which lie next the cortex (*fig. 3*), but become much thinner walled toward the center of the stem where they often appear to be in a formative condition. The strands are separated radially by rather wide areas of fundamental tissue (*fig. 2*), but in consequence of the general and great alteration in relative positions effected by compression, it is impossible to determine their original distribution. The radial distribution of these strands through a rather wide zone would seem to indicate that they may have been developed in more or less well defined concentric layers, a relation which is certainly implied by their distribution within certain areas (*fig. 2*). Beyond a limit of 1.5^{mm} from the surface the development of the strands appears to be wholly arrested.

VASCULAR BUNDLES.—The vascular bundles are not frequently represented, since in most cases they have been removed by decay, or other causes, and their former positions are then marked by the presence of rather broad, irregularly rounded openings of variable dimensions, which appear throughout the transverse section (*figs. 1, 2*, and *3*), and particularly internal to the sclerenchyma zone. Occasionally the bundles are preserved in a very perfect manner, and exhibit all their essential structural features with great clearness (*fig. 1*). The outermost of the two bundles seen in *fig. 1*, when much enlarged (*fig. 4*), is found to consist of several broad scalariform ducts enclosed on two sides by rows of thick walled fibrous elements. The phloem, rather small in volume, is here much broken down, but it is situated radially outward, while in the other bundle (*fig. 1*), where it is rather more perfectly preserved, it is situated radially inward. The protoxylem is here seen as a group of smaller elements much altered by compression (*fig. 4*), or in other instances more perfectly preserved (*fig. 1*), sometimes on the outer face of the vessels, and sometimes on the inner face, but always between them and the phloem. While the bundles vary considerably in size, they all conform to the collateral type and it is of interest to note that in all their structural features, they agree very closely with the bundles of a species of Myeloxylon described by Solms-Laubach,[8] and also by Seward.[9]

From the present material I have been wholly unable to obtain satisfactory details of the structure of the bundle in longitudinal section, beyond the fact that the vessels are distinctly scalariform, and in this respect they conform to the type generally observed in ferns.

The peculiar situation of these bundles is not altogether easy to account for. They certainly appear to lie between, and are therefore mingled with, the strands of sclerenchyma, from which circumstance I was at first led to suppose them to be collateral, as in the case of Phoenix and other palms, but a very careful examination fails to disclose any satisfactory evidence of such relationship, while in some cases at least the vascular bundle is separated from the nearest sclerenchyma strand by a broad zone of fundamental tissue. Indeed, the evidence, so far as obtainable from the present material, seems to indicate that these bundles and the sclerenchyma are altogether independent of one another; but in the present unsatisfactory condition of the material now available, no final conclusion can be drawn. From the evidence at hand, however, it would seem that the vascular bundles have their extreme outward distribution in the central portion of the sclerenchyma zone. From this position they increase in number toward the center and become most numerous within the central region.

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[8] Foss. Bot. 161, *fig. 14 B.*

[9] Ann. Bot. 7: *pl. I* and *II*, *figs. 1, 9, 14.*

SECRETORY ORGANS.—A notable feature of the present fossil is the occurrence of numerous large mucilage passages. As a rule these structures are much altered by decay and compression, but in two instances they were found in a very perfect state of preservation (*fig. 2*). So far as it is at present possible to determine, these organs occur throughout the sub-cortical region where they are in more or less intimate association with the sclerenchyma strands. Elsewhere it is not possible to determine the distribution satisfactorily, but, from our knowledge of their occurrence in recent plants, it is a fair inference that they must also be distributed through the entire body of the fundamental structure.

Measurements of such of these passages as were in a sufficient state of preservation for such a purpose showed them to have the following dimensions: $155 \times 100\mu$; $205 \times 135\mu$; $215 \times 145\mu$. From these results it is possible to deduce an average dimension of $127 \times 192\mu$. From this again it appears that these passages may be described as of elliptical form, in which the minor and major axes have a ratio of 1 : 1.5. The very great size of these structures, unusual except in a few groups of plants, seems to suggest a comparison with both Cycadaceæ and Marattiaceæ. In structure they are simple. Longitudinally they form long tubular passages which traverse the stem for great distances. In transverse section they consist of large elliptical openings bounded by a very regular wall composed of parenchyma cells often differing but little from those of the surrounding tissue. They are more commonly somewhat elongated tangentially to the central canal, and by analogy with similar structures in recent plants we may infer that they contained active protoplasm. They thus form the secretory cells, or an epithelium which is not specially differentiated (*fig. 3*). A comparison of the two canals (*fig. 2*) will serve to show, however, that the secretory cells often show little or no deviation from the general character of the fundamental structure.

Another important feature of these canals is to be found in the fact that they are always devoid of contents. This appears to justify the view that whatever they may have contained originally was of a soluble nature and thus passed out of the body of the plant during the process of petrifaction.

In all their principal structural aspects these canals bear a strong resemblance to those of *Angiopteris evecta* (they are of the same type), and it may also be pointed out that they are similar to those found in *Rachiopteris Williamsoni* which Seward has recently separated from Myeloxylon,[10] as also to those of Myeloxylon itself.[11]

Throughout the transverse section of the Topeka specimen there are numerous resinous or coaly masses of very variable size, but evidently originally contained in special channels or cells, which have become much disorganized, and the details of which cannot now be made out. In longitudinal section these masses are of indefinite length, but rather frequently septate. From these features it is possible to refer them to the residue of resin masses which the plant originally contained, and they are, therefore, directly comparable with the similar resin bodies found in recent plants, particularly those of *Angiopteris evecta.*

It is thus fairly certain that in the Topeka plant there were originally at least two, and possibly more, kinds of secretory organs, the one holding mucilage, the other resinous matter, and in these respects our plant is once more comparable with certain recent forms.

The general view of the internal structure thus obtained permits us to gain some conception of the real composition of this stem or stipe, from which we may infer that a restoration would show a cortical layer of parenchyma at least several layers of cells thick, containing numerous mucilage passages. Following this is a sub-cortical zone distinguished by the presence of numerous rather widely separated strands of sclerenchyma, the elements of which are very thick walled toward the cortex, but continually thinner walled toward the medulla. These strands usually have an accompanying mucilage passage on the outer face, and are in constant (?) process of formation toward the center. Within this zone, vascular bundles, distinguished by their broad scalariform vessels, appear, and increase in number toward the central region. The central axis consists of a rather broad tract of parenchyma tissue, through which the vascular bundles are distributed in large numbers.

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[10] Ann. Bot. **8**: *pl. XIII. figs. 8 11 C*^{iv}.

[11] Ann. Bot. **7**: *pl. I. figs. 1, 9.*

From this point of view, and with due allowance for the effects of compression, it is possible to trace a striking similarity in several respects to a species of Myeloxylon described by Solms-Laubach,[12] and more particularly in certain respects to specimens of Myelopteris described by Williamson.[13] The evidence is both clear and direct that this plant must be considered as belonging to that peculiar group for which the name Myelopteris, proposed by Renault, has been most generally employed.

In 1832, Cotta described certain fossils from the Carboniferous of Europe under the name of Medullosa, which has more recently become merged in that of Myelopteris. Williamson, however, informs us that Cotta's figures of *M. elegans* are wholly misleading, the structure being represented in a much exaggerated form, while his two species, *M. stellata* and *M. porosa*, remain too obscure to be depended upon without further evidence than has come down to us.[14] The genus Medullosa, nevertheless, constitutes the basis of that group of plants which, passing under several names, has finally come to be known under that of Myelopteris.

In 1845, Corda assigned to his genus Palmacites two plants from the Coal Measures of Bohemia, under the names of *P. carbonigenus* and *P. leptoxylon*.[15] An examination of Corda's figures shows that there is no very great resemblance, although there is a suggestion of similarity to our plant in the general character of the fundamental tissue, and the presence of numerous mucilage passages. These latter, however, are small and apparently altogether separated from the vascular bundles.

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[12] Foss. Bot. 161, *fig. 14A.*

[13] Foss. plants of the Coal Measures. Phil. Trans. **166:** *figs. 1, 3, 4.*

[14] Foss. plants of the Coal Measures. Phil. Trans. **166^1**.

[15] Flora der Vorwelt 40, 41. *pl. 19, 20.* 1845.

Subsequent observers have not been unmindful of certain structural aspects in these plants, which have seemed to suggest their possible relationship to the palms, and more particularly to that type of structure represented in the genus Dracæna, but much doubt has always been entertained as to the possibility of monocotyledons occurring so far back as the Carboniferous. These doubts were first prominently expressed by Brongniart as the result of comparing with the plants figured by Cotta and Corda, new material obtained from Autun, France.[16] He says "il y ait des différences fort essentielles et què rendent très difficile d'établir des rapports entre ces fossiles et les végétaux vivants." He therefore preferred to regard Cotta's *Medullosa elegans* as the representative of a new genus, for which he proposed the name Myeloxylon, which thus seemed to indicate the leading structural features indicated by the former name, the significance of which was thereby perpetuated.

Fifteen years later, Goeppert, in reviewing Cotta's species, regarded *Medullosa elegans* as possessing characters which were variously represented in the gymnosperms, in palms, and in the ferns. As a generalized type, he applied to it the name of Stenzelia.

In 1873, Williamson first drew attention to the belief that the relations of these fossils had not been correctly interpreted, and expressed the view that they were really ferns allied to the Marattiaceæ.[17]

In 1874, Renault reviewed the fossils obtained from the Carboniferous beds at Autun, as a result of which he supports the conclusions reached by Williamson, and while he regards the name proposed by Corda to be wholly untenable, and those of Cotta and Goeppert to be insufficiently indicative, he views that of Brongniart with favor, but regards a different form as more expressive of the relationship which he determined.[18] He therefore says: "Pour conserver le nom, premier en date, donné par M. Brongniart à ces portions de plantes, et en même temps pour rappeler leur nature, je les designerai sous le nom de Myelopteris."

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[16] Tab. des gen. de Vég. Foss. 60. 1849. (Quoted from Williamson.)

[17] Brit. Ass. Adv. Sci. 1873.

The yet more recent studies of these plants by Williamson led him to admit the force of the arguments employed by Renault and the appropriateness of his name.[19] Reference to Williamson's figures discloses several points of resemblance between his specimens and my own. This is to be noted first in a great similarity with respect to the general distribution of tissues, particularly as exhibited in his *figs. 3* and *4*, as likewise in the very general removal of the vascular bundles. The vascular bundle given by him (Williamson, *fig. 7**) is closely similar to that derived from the Topeka specimen (*fig. 4*), but differs materially from his other representation (Williamson, *fig. 7*) taken from the upper end of a rachis, which is closely similar to bundles observed by me in *Dioon edule*, whereby it offers some basis of comparison with the Cycadaceæ.

In longitudinal section the resemblance is rather close, but in this aspect the Topeka specimen offers little evidence of a satisfactory nature beyond the general relations of parts, and the structural markings of the vessels which are seen to be scalariform, as in the ferns.

Finally, the relation of the mucilage passages to the vascular bundles (Williamson, *fig. 14*) and of the very large, elliptical mucilage passages to the sclerenchyma strands (Williamson, *fig. 13*), as also the very thin walled elements of the fundamental structure, all present features almost identical with those observed in the Topeka specimens (*figs. 1, 2, 3*).

Williamson's specimens appear to differ from my own chiefly with respect to the particular distribution of the sclerenchyma strands in the cortical region, a difference which, however, is more specific than generic, but my material has been so altered by compression that I should hesitate to place much reliance upon these aspects of structure, preferring rather to establish the affinity by means of the more perfectly preserved structural elements.

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[18] Recherches sur les végétaux silicifiés d'Autun. (From Williamson.)

[19] Fossil plants of the Coal Measures. Phil. Trans. 166^{I}.

The distribution of the vascular bundles in concentric zones, as described by Williamson, may also be a feature of the Topeka specimen, but for reasons already stated this cannot be asserted with any degree of confidence.

More recently Solms-Laubach[20] has reviewed the entire relations of this group of plants, and while he rejects Renault's name because he regards the evidence as not altogether satisfactory, he prefers to retain Brongniart's name of Myeloxylon "rather than Stenzelia, because it is better known." He gives two figures, one of a general transverse section, the other of a separate vascular bundle, and it is of considerable interest to note that this latter is almost the exact counterpart of a vascular bundle obtained from the Topeka fossil (*fig. 4*). His general view of the structure is not so satisfactory, but it nevertheless exhibits a close similarity to my own material in all its principal features.

Solms-Laubach dissents from the conclusions of both Renault and Williamson, holding that there are strong reasons, on anatomical grounds, for considering the alliance to be with the Cycadaceæ, and cites *Medullosa Leucharti* as probably affording important evidence in support of this view.

The most recent contribution to our knowledge of these plants is that offered by Mr. A. C. Seward, who has not only reviewed the material originally described by Williamson, but has made a detailed study of specimens contained in the Binney collection of the Woodwardian Museum, Cambridge, as well as of new material derived from the Millstone grit of Lancaster.[21] The diagnoses show that his material is generically the same as that represented by the Topeka specimens as described. In a second paper, the same authority makes a study of certain specimens contained in the Williamson collection and originally included by Williamson in the genus Myelopteris, but which he finds to be in reality quite distinct. He therefore separates them under the name of *Rachiopteris Williamsoni*.[22] This species is quite distinct from our Topeka specimen with respect to the character of the vascular bundles, which are concentric, and thus show a distinct approach to the type represented in *Angiopteris evecta*. On the other hand, the mucilage passages, which are also of the type found in Angiopteris, are essentially the same as those of the Topeka specimen, differing only in distribution.[23]

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[20] Foss. Bot. 161. 1891.

[21] Ann. Bot. 7:1.

From the review thus presented, it is quite clear that our specimen must be regarded as a species of myelopteris, according to the name adopted by Renault and Williamson, and retained by me as expressing its probable relations, but that it differs specifically from any of the specimens heretofore described. It may be concluded further that the present material represents the stipe of a frond, rather than the stem proper.

Heretofore the representatives of this genus have been derived wholly from the Carboniferous of Europe. The material now at hand from the Upper Carboniferous of Kansas thus affords important evidence as to the wider geographical range of these plants, while the well preserved condition of portions of its structure permits a further discussion of its possible affinities. I have, therefore, carefully passed in review such species of living plants as are available in the Botanic Gardens of McGill University, as affording a possible solution of this question. In prosecuting these studies, I have had in view the suggestions of earlier investigators, as well as those which naturally arose in my own mind upon making a preliminary examination of these fossils. I have, therefore, carefully examined *Cordyline terminalis*, *Phoenix dactylifera*, *Kentia Fosteriana*,

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[22] Ann. Bot. **8**: 207.

[23] Ann. Bot. **8**: *pl. 13, fig. 8.*

Latania borbonica, *Cycas revoluta*, *Dioon edule*, *Zamia integrifolia*, *Cibotium regale*, and *Angiopteris evecta*.

A close comparison of the Dracæna type, as represented by Cordyline, shows that any suggestion of resemblance which might at first appear, has no real basis in structural characters, while in many essential respects there is a very wide difference. Noteworthy points of resemblance being absent, it is wholly unnecessary to enter into a more detailed consideration of the structural aspects of this type. Very nearly the same observations are applicable to the palms. In this group of plants, however, there is a somewhat closer point of contact to be found in the mucilage passages. Here these structures appear as tubular channels of great length, and in this respect, as well as in their distribution and great number, there is a general resemblance to the Topeka fossil. Their detailed structure is, on the other hand, quite different, and it points to a want of affinity which is supported by the structure and distribution of the vascular bundles, as also the character of the fundamental structure, and no very searching comparison is required to establish the fact that the affinities of our fossil must be sought elsewhere.

By several authorities the Cycadaceæ have been suggested as affording a satisfactory basis of comparison, a view which, in more recent times, appears to have been particularly urged by Solms-Laubach,[24] although he elsewhere agrees with other observers that certain exceptions which have been taken to the cycadaceous character of the Medullosæ are well founded.[25]

Mr. Seward, yet more recently, has given expression to the same view, basing his opinion upon a very critical examination of a large amount of material.[26] While admitting the many points of resemblance to ferns, he holds that in the position of the protoxylem and in the structure of the mucilage passages, as also in the distribution of the sub-cortical sclerenchyma, there are strong reasons for considering the affinity to be with

[24] Foss. Bot. 161.

[25] *Ibid.* 100.

[26] Ann. Bot. 7: 18.

the cycads rather than with the ferns. Without hoping to settle this question at the present time, it may be profitable to consider some of the arguments advanced by Mr. Seward in the light of evidence obtained from an examination of material derived from existing species, as also from the Topeka specimen itself.

VASCULAR BUNDLES.—An examination of both cycadaceous plants and *Angiopteris evecta* affords but little evidence contrary to the view urged by Mr. Seward. The evidence obtained shows, as he contends, that the position of the protoxylem in these plants is certainly an argument in favor of the cycadaceous character of Myeloxylon. On the other hand, the collateral character of the vascular bundles in the latter cannot be taken as final evidence of affinity either with the ferns or with the cycads, as Mr. Seward himself points out. Although the longitudinal sections of the Topeka specimens have given far from satisfactory results, the evidence to be derived from them indicates a much closer resemblance to Angiopteris than to any of the cycads I have been able to study.

SECRETORY ORGANS.—In the Cycadaceæ, as represented by *Cycas revoluta*, *Zamia integrifolia*, and *Dioon edule*, the secretory organs appear to be all of one kind as represented by mucilage canals. These structures are distributed throughout the fundamental tissue and are represented by broad canals which are chiefly limited by tangentially elongated parenchyma cells. These latter, therefore, differ somewhat conspicuously from the cells of the surrounding tissue, as already shown by Mr. Seward.[27] So far as appears from the species above indicated, however, these canals are always lined with a layer of very thin-walled epithelium cells, which become ruptured with age and, shrinking back upon the main wall of the canal, give it a thickened and very ragged appearance.

In *Angiopteris evecta* there are three distinct kinds of secretory organs: (*a*) tannin sacs, (*b*) resin canals, and (*c*) mucilage canals.

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[27] Ann. Bot. 8: 214.

Tannin sacs.—In transverse section the tannin sacs are often barely distinguishable from the resin canals, by reason of their structural similarity. They occur abundantly in the cortex and throughout the fundamental tissue, and especially in close proximity to or within the limits of the vascular bundles. To me these appear to be the structures referred to by Mr. Seward in his description of *Rachiopteris Williamsoni*, when he says, "there are smaller canals in the peripheral part of the phloem of each bundle."[28] In longitudinal section these sacs are seen to be of about the same diameter as in the transverse section, except in the cortex, where they assume the form of cylindrical cells about three or four times longer than broad. The contents are much lighter colored than those of the resin canals, and often present a well defined granular appearance. They readily yield the characteristic reactions for tannin.

Resin canals.—Throughout the sub-cortical zone, scattered among the sclerenchyma cells and also central to each of the isolated strands, are rather broad canals of indefinite length. Throughout the fundamental tissue, particularly in the neighborhood of the vascular bundles, there are also numerous canals which differ but slightly in their structural aspects from the surrounding cells. In all cases, however, they are at once recognizable by the rather dark red resinous mass which each contains. In longitudinal section the canals are of indefinite length. The contents are often septate. These structures appear to me to be comparable with the black, resinous masses of variable size to be met with not only in the Topeka specimen, but in most of the European specimens of Myeloxylon.

Mucilage canals.—Throughout the ground tissue of Angiopteris there may be seen broad openings bounded by more or less tangentially elongated cells. These are the canals from which issue the very large volume of mucilage freely liberated when the stipe is sectioned. These canals are always limited by cells which differ but little from those of the surrounding tissue, except that they are more or less elongated tangentially. Here there is no specially differentiated epithelium, and in this respect we meet with a feature which serves to sharply separate these structures from those of the Cycadaceæ. On these grounds I should feel no hesitation in deciding as to whether a given plant were cycadaceous or filicoid in its affinities. From this point of view, then, it would seem that the Topeka specimen is more nearly allied to ferns, and the same would hold true of Myeloxylon, if we are to base an opinion upon the excellent figures of Mr. Seward.

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[28] Ann. Bot. **8**: 214.

SUB-CORTICAL SCLERENCHYMA.—The distribution of the sclerenchyma can hardly be taken as an argument one way or the other, since in both ferns and cycads there is such wide variation. I should consider this a specific rather than a generic character. In all of the myeloxylons so far studied, the sclerenchyma is distributed in separate strands. In the cycads studied by me this tissue forms a continuous band in all cases where strongly developed. In Angiopteris it forms a continuous zone of considerable thickness, with separate strands lying along the inner face.

A résumé of the results above detailed shows that in the Topeka specimen there are characters which directly connect it with *Rachiopteris Williamsoni*, and also with other European species of Myeloxylon, and the evidence would seem to indicate that few of these can be separated generically. Admitting the force of some of the objections raised by Mr. Seward respecting the filicoid character of Myeloxylon, there are, nevertheless, strong arguments in favor of this view, which seem to me to preponderate and thus to justify the retention of the name Myelopteris as a name expressive of this possible relationship; while the fact that these plants do not conform closely to any modern type would seem to raise a question as to the possible correctness of the view originally expressed by Goeppert that these plants in reality represent a generalized type occupying a position between the cyads and the ferns.

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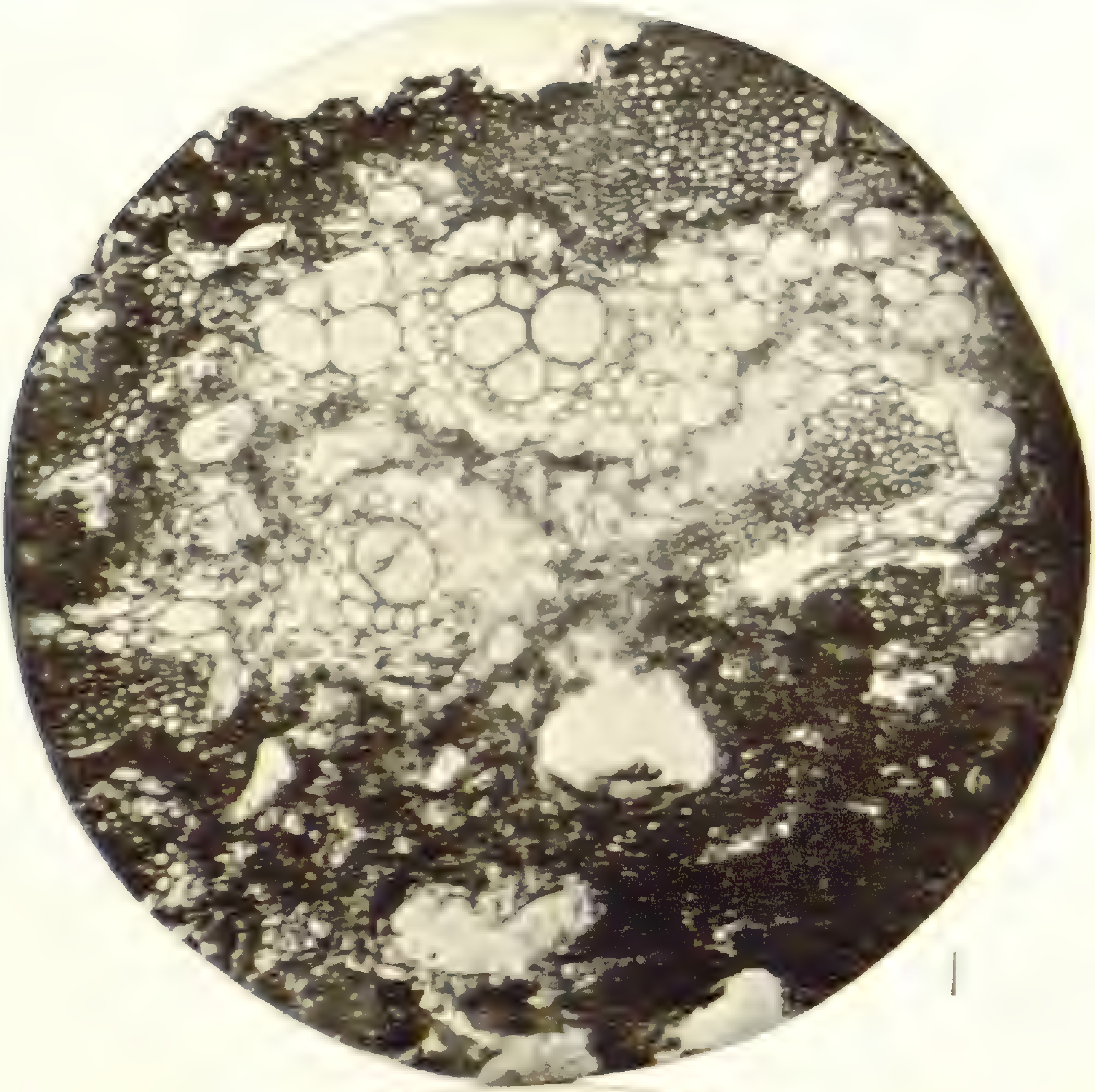

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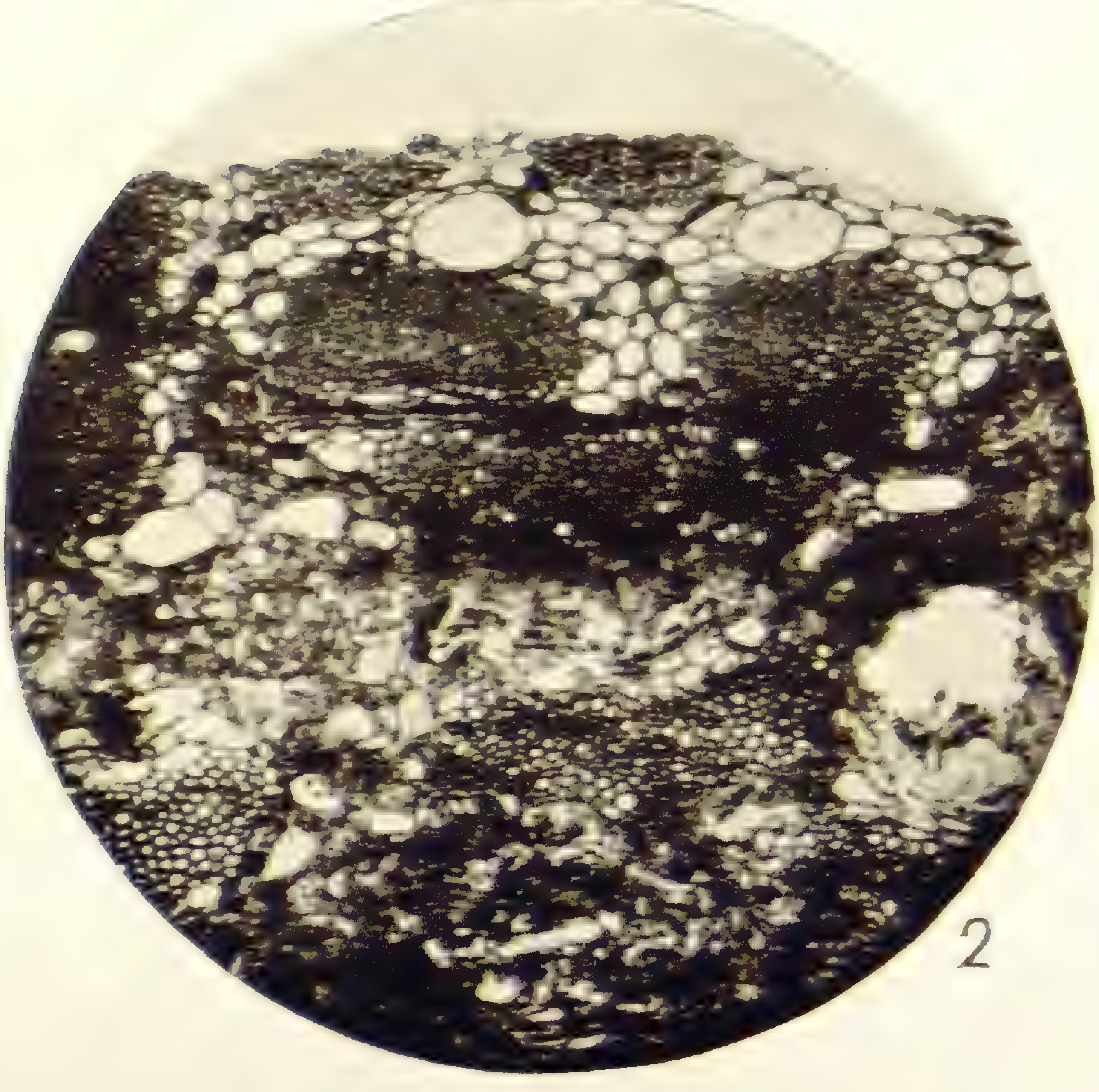

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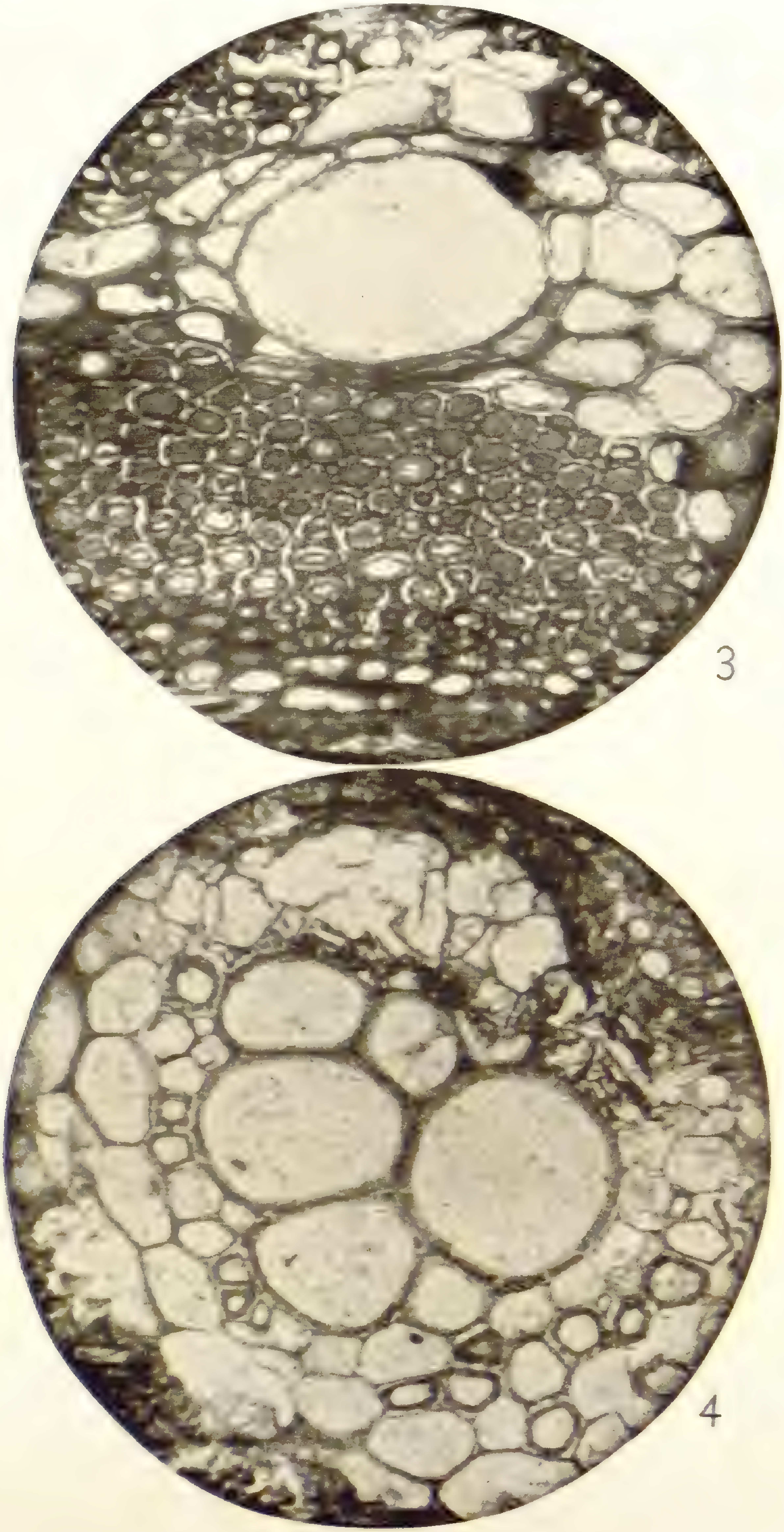
MYELOPTERIS TOPEKENSIS Penhallow.



MYELOPTERIS TOPEKENSIS Penhallow.

EXPLANATION OF PLATES II AND III.

PLATE II.

FIG. 1. Transverse section showing the sclerenchyma strands, the fundamental tissue, and two vascular bundles. × 48.

FIG. 2. Transverse section showing the sclerenchyma strands, with two large mucilage passages. × 48.

PLATE III.

FIG. 3. Transverse section of a sclerenchyma strand showing details of structure in a mucilage passage on its outer face. × 180.

FIG. 4. Transverse section of a vascular bundle showing details of structure. × 180.

A NEW QUILLWORT.

RAYNAL DODGE.

(WITH PLATES IV AND V)

IN the early summer of 1895, Mr. Alvah A. Eaton of Seabrook, N. H., noticed at East Kingston, in the same state, a plant which proves to be a new species of Isoetes. This plant was found on Powwow river "flats," which comprise a nearly level, somewhat irregular tract of land, about a half mile wide and a mile and a half long, through the middle of which during summer the Powwow river flows, but for six or eight months of the year the area is for the most part submerged. The plants are scattered all over this locality, being however not at all gregarious; some having been found in the latter part of July growing up to high water mark, accompanied by *Agrostis vulgaris*, *Poa compressa*, *Trifolium repens*, and various asters; whilst others were thriving in the river, immersed in six inches or a foot of water, and accompanied by such aquatics as *Scirpus subterminalis*, the plants in the latter instance floating their enormously long leaves on the surface. The soil in this locality is a deep alluvium underlaid with sand, and upon its surface, besides the Gramineæ and Junci which usually occupy such situations, several species of Isoetes grow, for the most part gregariously, among which I recognize *I. riparia*, *I. Engelmanni*, *I. echinospora Boottii*, and *I. echinospora muricata*. These are accompanied by the peculiar species which I propose now to discuss.

This interesting form, which I name *I. Eatoni* in honor of its discoverer, is seldom found growing very near another of its species, but the plants are from a foot to ten feet apart, and are thus dispersed throughout the station. It is noticed at a higher level than any of the forms with which it is associated, and if it does not also occur at a lower level, it at least has that appearance, for when in the deepest water it is surrounded by such a tangle of Gramineæ, Junci and Scirpi, that it is detected only by its long floating leaves, when shorter leaved forms would pass unobserved.

In common, I think, with all amphibious species of this genus native to New England and growing under the conditions mentioned, this species has two sets of leaves, differing somewhat in structure, but especially in dimensions, the longer constituting its spring dress when submerged, and the shorter its summer dress when living in the air and exposed to open sunlight. The vernal leaves are very long, sometimes attaining the length of 28^{in}, but as I have seen them only in early summer, when by the falling of the water their upper portion was floating and decaying, I am not sure what position they assume when wholly submerged, but I suppose they are erect spreading.

By further recession of the water, these vernal leaves become prostrate and soon decay to the base, which usually remains covering the sporangium, the spores maturing only when for some weeks exposed to the air and sunlight. The plant now produces within the old a new set of leaves which, excepting the central ones, are nearly decumbent, the matured spores and dead portions being gradually thrown off by the downward lateral growth of the corm. These æstival leaves are from 3 to 6^{in} long, with a more or less pronounced lateral curvature which serves to distinguish this plant from the larger forms of *I. Engelmanni.* The outermost of these æstival leaves are found late in the season to include at their bases matured sporangia; in fact, on the highest ground, the plants getting an earlier start perfect their spores during the whole summer and early autumn. These outermost and matured leaves then decay, but the inner and immature remain, are covered by water, survive, probably even in winter vegetate to some extent, and on the approach of warmer weather undergo a rapid increase in dimensions, as evidenced by a plant kept in a jar of water during the past winter, which, beginning early in April, in a few weeks increased the length of its leaves threefold.

Full grown plants of this species are immediately recognized among others with which they may chance to be associated, when immersed by their long floating leaves, and when emersed by the very large diameter of their assembled macrosporangia, which in one instance in a fresh plant was $2\frac{3}{4}^{\text{in}}$, a diameter of 2^{in} being common; but it may be remarked in passing that desiccation produces a shrinkage of from 25 to 40 per cent.

Thus *I. Eatoni* is unsurpassed in dimensions by any known North American species, and only equaled, if at all, by Engelmann's *I. Engelmanni valida*, which as yet has not been noticed in the New England states. *I. Engelmanni*, with which our present species has perhaps been confounded, is abundant in eastern Massachusetts, growing in nearly every brook and slow running stream, and is quite common even in ditches, but I have not seen plants with leaves more than 16^{in} long, nor with bulbs more than an inch in diameter, specimens of this size being quite unusual. The number of leaves in full grown plants of *I. Eatoni* varies from 50 to nearly 200, the greatest number yet noticed having been 187.

The most striking characteristics of this species are: the paucity of microspores; the irregular occurrence of peripheral bast bundles in the leaves; the peculiar sculpture of the macrospores; the straightness of the commissural ridges; and the low angle they form with the equatorial plane. Previous to drying the well grown plants of this species, large and filled with moisture as they are, it is well to cut each plant into two parts, making a section at right angles to the natural division of the trunk. I have divided a great many in this way, but in the largest no sporangia containing microspores have as yet been detected. Several plants have been noticed which contained from ten to thirty microsporangia, and few or no macrosporangia, and about a dozen which held microsporangia irregularly scattered among the others. On the other hand several hundred plants which have been examined apparently contained only macrospores.

It has been remarked by Alexander Braun and other European students of the Isoetaceæ that the largest plants of a given species contain relatively the fewest microsporangia, but I think that no such extreme instance as this of our present species has been recorded, and it is quite in contrast with the habit of *I. Engelmanni*, its nearest congener, in which microspores can always be found, excepting when the plants are very small or poorly developed.

The larger plants of *I. Eatoni* produce annually thousands of macrospores, probably continuing to do so for many years, and yet the station where this species occurs is far from being fully occupied, so that this infrequent occurrence of the microspores would seemingly account for the dispersed manner in which the plants are found to grow. It is to be noted, on the other hand, that the sporangia are very large, often a half inch long, each microsporangium containing doubtless several million spores.

The leaves of *I. Engelmanni* are found always in my experience to contain peripheral bast bundles. In this species they are present in some leaves, but not in others of the same plant, and from some plants they are apparently altogether absent. They are often weak, but occasionally well developed, and occupy the same position as in *I. Engelmanni*.

Those who are familiar with the classification of the species of Isoetes, as elaborated by A. Braun and adopted by Engelmann, Baker, and Motelay, will notice that the position of *I. Eatoni* is quite abnormal when considered in reference to its mode of growth and to the presence of bast bundles.

The sculpture of the spores in this species is labyrinthiform-convolute, having about the same appearance as brain coral, the walls being wide, and not, as in *I. Engelmanni*, composed of thin fragile laminæ.

A marked feature of the macrospores is that the commissural ridges are perfectly straight. The angle which these ridges make with the equatorial plane of the spore is sometimes so low that the upper end of the spore is very flat, but the average angle is about twenty-five degrees. This gives the spores a tetrahedro-globose form, sometimes noticed in the immature spores of other species, but a constant character in the matured spores of *I. Eatoni*. The macrospores are quite small, the commissural ridges usually cristate, and the epidermis of the sporangia, in *I. Engelmanni* unspotted, is in this species often covered with light brown sclerenchyma cells.

Although I have visited three times the locality in East Kingston where this species occurs, I am yet indebted for many of the foregoing facts to the discerning eye and untiring efforts of Mr. Eaton himself, who has taken much interest in the inconspicuous but interesting plants of this family.

Isoetes Eatoni, n. sp.—Trunk stout, 6–48^{mm} in diameter, bilobed, diameter of bulb sometimes 66^{mm}: vernal and immersed leaves 50 to nearly 200, 38–71^{cm} long, with an elevated ridge on the ventral side, strongly winged near the base, the wing decurrent into a broad (3^{mm}) hyaline margin, which is furnished with slender irregular hooked teeth, median section nearly triangular in outline; æstival leaves much shorter, 7.5–15^{cm} long, the outer nearly decumbent, median section approaching quadrangular; stomata abundant: peripheral bast bundles of irregular occurrence, often weak or wanting: sporangia maturing only when emersed, large, oblong, strongly arcuate, in well grown plants 10^{mm} long and 4^{mm} wide, nearly covered with very light brown sclerenchyma cells: velum about one-fourth indusiate: macrospores small, tetrahedro-globose, equatorial diameter 300–450μ, sculpture labyrinthiform-convolute, commissural ridges cristate: microspores 25–30μ in length, smooth or slightly papillose: plant polygamous.

Discovered by Mr. Alvah A. Eaton on the "flats," Powwow Station, East Kingston, N. H. One plant of this species has been found on the tidal tract of the Merrimac river at Newburyport, Mass., and a large number at Pautuckaway river, Epping, N. H., one of the latter being trilobed.

An interesting problem relating to the quillworts is as to the chemical nature of the clear white covering of the macrospores. It has the appearance of calcium carbonate and one almost expects to see it dissolve with effervescence in dilute acids, but a trial shows that no such action takes place. Reference to all accessible authorities has led to the unexpected result that apparently no investigation of this subject has been made. Dr. Engelmann speaks of this integument as "a crust, chalky white;" Sachs is silent, as is the Micrographical Dictionary; Hofmeister says "the matter composing the exosporium behaves towards reagents like the exine of pollen grains. Sulfuric acid imparts a reddish color to the inner layers which are softened by boiling in alkaline lyes. The gelatinous layer is *rapidly destroyed by mineral acids* and caustic alkalies. Röper has observed that the exosporium does not contain calcium carbonate, although Schleiden suspected its presence from the appearance of the dry spores."

Experiments conducted with a view of becoming better acquainted with the chemical nature of the exosporium have led to the following results. The macrospores when strongly heated become brown and then black, and if the heat be increased to bright red, they still retain their form and sculpture and are white when cool. The exosporium is easily soluble in a solution of sodium hydroxide; it gelatinizes somewhat in boiling sulfuric acid, but after washing and cooling the macrospores *have the same outward appearance as before treatment.* By the action of potassium chlorate and nitric acid the endosporium is entirely destroyed, and the exosporium of many of the macrospores is fractured, but undergoes no other appreciable change. The exosporium dissolves rapidly in fluorhydric acid, and if to this solution sodium chloride be added, we obtain the characteristic hexagonal crystals of sodium silico-fluoride; the microchemical test with sulfuric acid for calcium oxide shows its presence in minute quantities. No traces of potassium were detected with the spectroscope.

One hundred parts of macrospores which had been for several months air dried were found to suffer a

Loss at 100° C. of - - - - -	4.11
Loss by burning - - - - - -	20.96
Residue - - - - - - -	74.93
	100.00

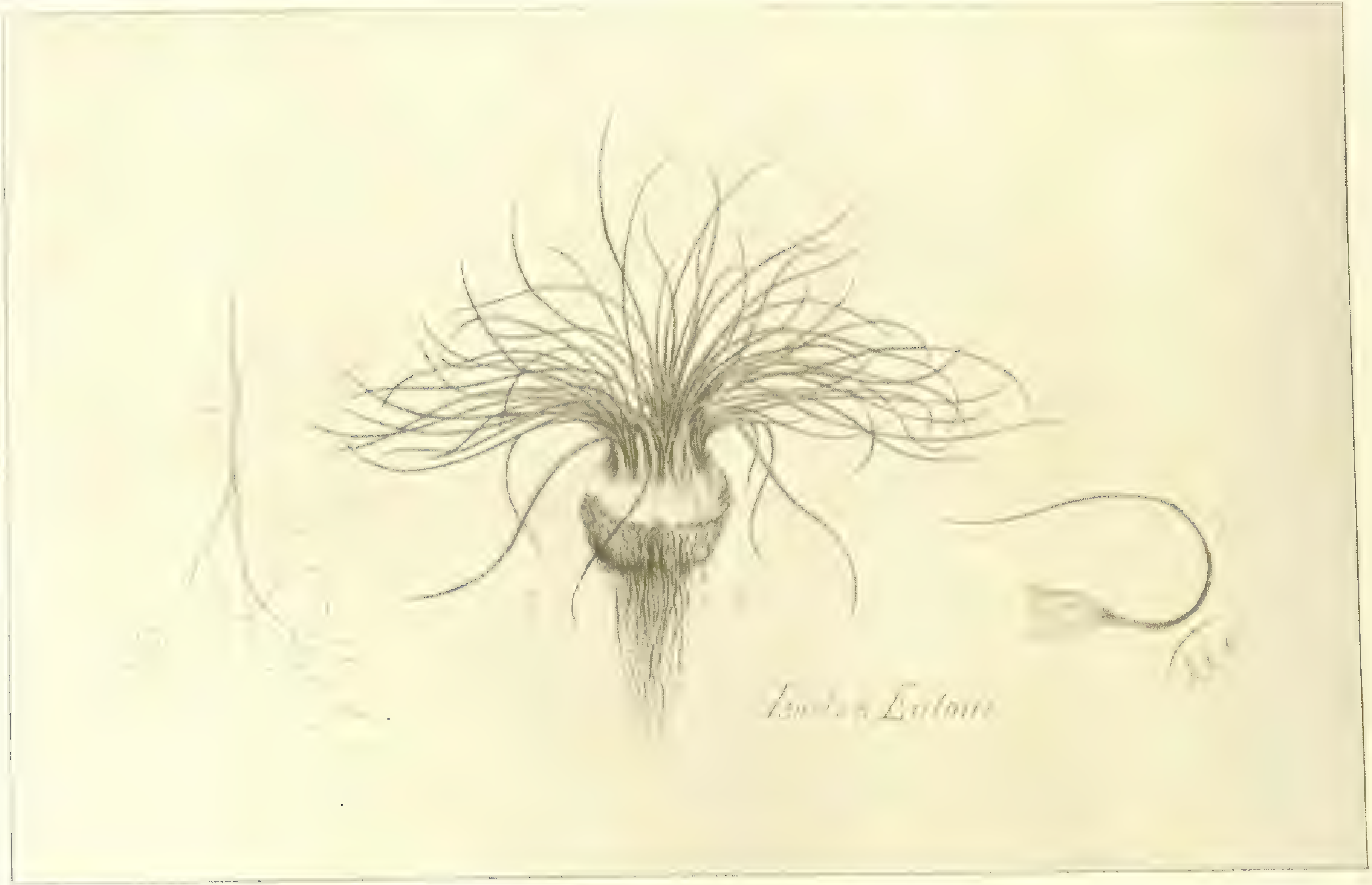
No attempt was made to determine the amount of incombustible matter in the exosporium, as it was found rather difficult to collect it in sufficient quantity. It is evident from the foregoing reactions that the residue is very largely silica.

We also find by calculation that the incombustible residue forms 78.14 per cent. of the spores dried at 100° C. The macrospores when divested of their exosporium are found to be very combustible, leaving when pressed on white paper a transparent stain, and can hardly be supposed to contain less organic matter than the exosporium itself. If we adopt this supposition, we find that the integument contains about 90 per cent. of silica, which is a very large amount when we consider that the ashes of oat straw contain less than 5 per cent.

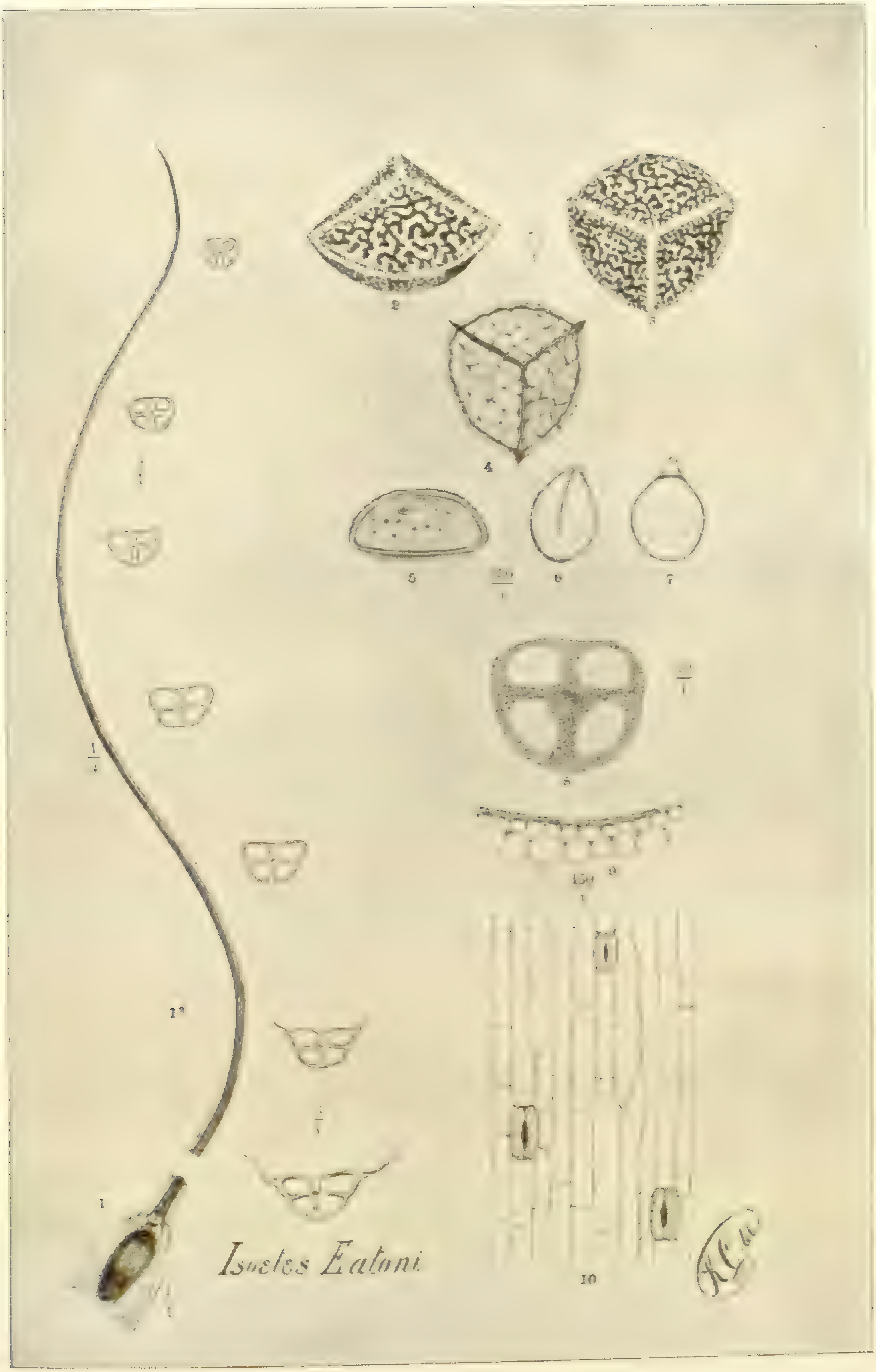
It is quite possible, moreover, that the blackening of the macrospores when they are first subjected to heat is caused by discoloration from the gases produced by the ignition of the endospore; indeed it is questionable whether the exosporium contains organic matter. This naturally could only be decided by the collection and examination of a considerable amount of the integument, an undertaking that requires a larger opportunity and better facilities than the author has been able to bring to bear upon it.

It is perhaps worthy of remark that *I. Eatoni*, from its polygamous character and the number and size of its macrosporangia, furnishes, with but little labor, a large amount of macrospores free from microspores, and it was upon the macrospores of this plant that the previously mentioned experiments were made.

An examination of *pl. V, fig. 4* will show that a macrospore of *I. Eatoni* when divested of its integument is marked by faint ridges. In the case of *I. Engelmanni* these ridges are reticulated, and the endospores of *I. echinospora* are dotted with small low tubercles. It is at these little elevations that the spore secretes the greatest amount of silica, and it is this extra secretion that gives character to the so called spore sculpture. But it is evident that these silicious markings of the exospore are not produced by sculpture, or by any analogous process, and it is suggested


Isoetes Eatoni

ISOETES EATONI Dodge.


1
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6
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10
Isoetes Eatoni

ISOETES EATONI Dodge.

that *silicia*, *i. e.*, formed from silica, would be a more appropriate term.

For the foregoing chemical investigations, as also for drawings and photographs, I am in a great measure indebted to Mr. Karl Castelhun of this city.

NEWBURYPORT, MASS.

EXPLANATION OF PLATES IV AND V.

PLATE IV.

FIG. 1. Æstival form of *Isoetes Eatoni*.

FIG. 2. Leaf from same plant.

FIG. 3. A portion of one of the dichotomously branched roots.

PLATE V.

FIG. 1. Base of vernal leaf, which remains attached to the plant for a time after the upper portion, 1 *a*, has decayed. Transverse sections of a vernal leaf, at points about four inches apart, are shown by the small figures at the right of 1 *a*.

FIGS. 2 and 3. Macrospores.

FIG. 4. Macropore from which the integument has been removed by the action of potassium hydroxide.

FIGS. 5–7. Microspores.

FIG. 8. Median section of an æstival leaf.

FIG. 9. A portion of the same more highly magnified, showing the cuticular membrane beset with numerous small protuberances, the epidermal cells, and the parenchyma.

FIG. 10. Fragment of epidermis showing stomata.

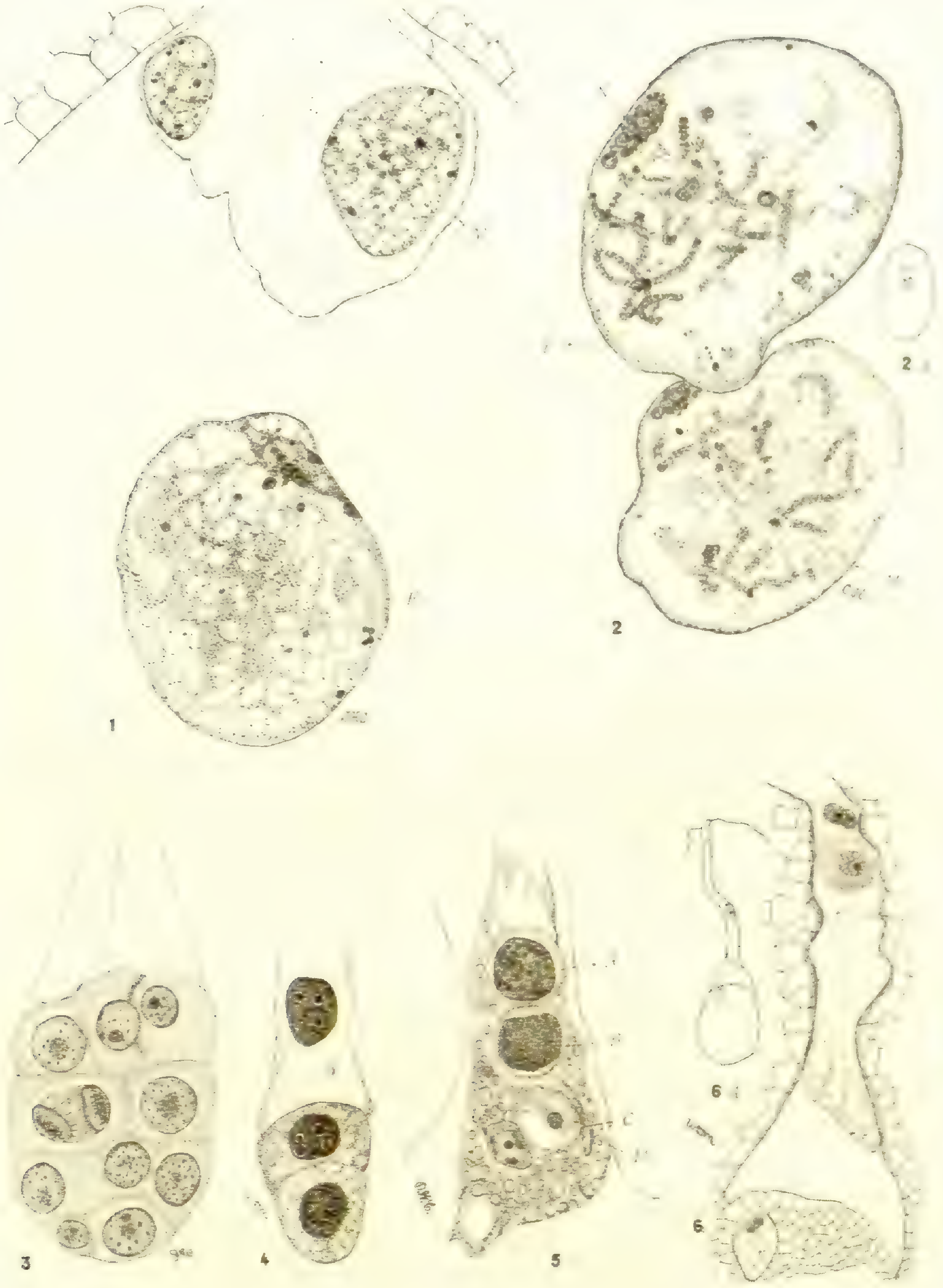
BRIEFER ARTICLES.

NOTES ON THE FERTILIZATION AND EMBRYOGENY OF CONIFERS.

(WITH PLATE VI)

During the autumn quarter of 1896 a group of graduate students under my direction made a study of the special morphology of gymnosperms. The necessities of the material restricted critical work to the conifers, and among them *Pinus* and *Taxus* were represented by the most complete series of stages. The problems of special interest were those of fertilization and embryogeny, following such papers as those of Belajeff, Dixon, and others. The work was supplementary to the regular research work among angiosperms in which each student is engaged, and preparations made for classes in elementary morphology were freely used. As a consequence, the material was sometimes in such a condition of staining, etc., that some points of critical interest could not be cleared up by proper technique. The work of the authors referred to was largely confirmed in the minutest details, but in looking over the results of the quarter it occurred to me that enough additional observations had been made to justify this somewhat informal record. It would be strange if the examination of large series of well made preparations by seven or eight trained observers did not result in something noteworthy, especially in a group so little studied. The drawings of the accompanying plate have been made by each student from whose work some observation has been taken, and whose notes furnish the substance of my comment. All the figures were drawn with a $\frac{1}{12}$ immersion and an Abbé camera lucida, excepting *fig. 6*, which was drawn with a $\frac{1}{6}$ dry lens.

Figure 1 is contributed by Mr. J. H. Schaffner from his work upon *Pinus Banksiana*. It is stained with cyanin-erythrosin, and represents the upper part of the oosphere, into which a pollen-tube with two nuclei is penetrating, having passed through the neck of the archegonium. The two nuclei within the tube are those of the male cells, which were differentiated within the pollen grain, the difference in size


1
2
2 a
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4
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6
6 a

COULTER on CONIFERS

having been developed since entering the oosphere. In the case of *P. silvestris*, Dixon has observed that the tube nucleus and the stalk-cell nucleus may accompany the two male cells into the oosphere, but in this case no trace of these sterile nuclei could be found, and before the tube began to enter the oosphere they had given evidence of the beginning of disorganization. The most remarkable feature of the section, however, is the bulging of the female nucleus (F) towards the larger and nearer male nucleus (M). Mr. Schaffner has observed[1] a similar bulging of the oosphere nucleus in *Alisma*, but in that case the whole side of the nucleus appeared to be drawn out, while in the case before us there is only a papilla-like protuberance.

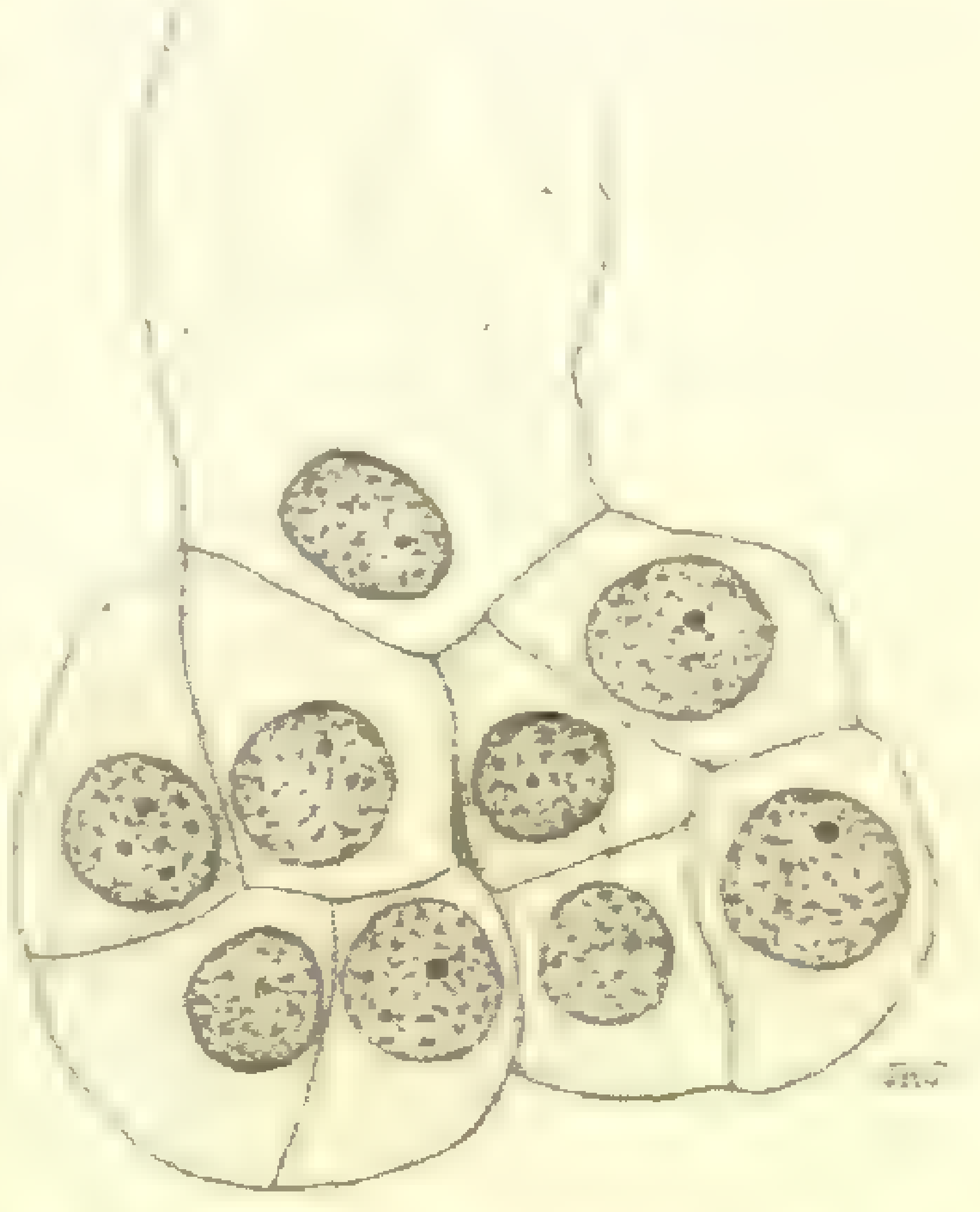

FIG. 1.—Two embryos with a single suspensor

Figure 2 is contributed by Mr. Charles J. Chamberlain, and is a fitting supplement to the stage found by Mr. Schaffner, although it was obtained from another species, *P. Laricio*, the common Austrian pine of the parks. The male (M) and female (F) nuclei are in the initial stage of fusion, the protuberance of the latter having decidedly indented the former. In 2A Mr. Chamberlain has outlined the embryo-sac in order to locate the pairing nuclei, which are nearer the micropylar end. It will be observed, therefore, that the male nucleus is not upon the side of its entrance, a shift in position which may be common, or it may be the accident of the section. The male nucleus also has increased in size until it approximates that of the female nucleus, an increase that seems to begin in the case of one of the two male nuclei when they enter the oosphere, as shown in *fig. 1*. In each nucleus the nucleolus (X) has broken up into numerous globules. In both cases, also, the chromatin filament shows plainly, and is probably in one continuous piece, the free ends being due to cutting, since the nuclei appear in three sections of the series. This state was discovered before that represented by *fig. 1*, and the sexual nature of the two nuclei was much in doubt. The micropylar position and the protuberance of the one seemed to argue for its male character, but the smaller size of the other was against its female character. As the preparation had been stained for ordinary class use it was a question whether sexual staining would be possible. The cover was removed, and an attempt was made to restain with cyanin-erythrosin, but the nuclei still stained alike. Dr. Watasé's researches on the sexual nuclei of animals show that at the moment of fusion the nuclei stain alike, while before fusion the male nucleus is cyanophilous and the female nucleus erythrophilous. However, the present attempt at sexual staining proves nothing, as the sections threatened to wash off, and consequently the staining was not prolonged enough to become decisive.

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[1] BOT. GAZ. 21: 127. 1896.

Figure 3 is contributed by Mr. John G. Coulter, and represents a young embryo of *Pinus Laricio* that has developed at the end of two, and probably four, suspensors. The general statement that in *Pinus* each of the four independent suspensors develops an embryo breaks down in this species. The statement usually runs that *Picea excelsa* is the single exception among the *Abietineæ*. In *Pinus Laricio*, however, the greatest variety was observed; sometimes an embryo to each suspensor; oftener an embryo to two or four suspensors, as in the figure; and in one case two embryos to a single suspensor, as shown in the accompanying cut, furnished by Mr. Schaffner. In the last case the primary segmentation was evidently longitudinal, the two resulting cells for some reason became physiologically dissociated, and each one of them proceeded independently to form an embryo.

Figure 4 is contributed by Mr. W. D. Merrell, and represents the first segmentation of an embryo of *Pinus Banksiana*. In this species it seems to be the rule for the first one or two segmentations to be transverse. Afterwards longitudinal divisions appear, beginning with the basal cell and including the apical cell. In *P. Laricio* the primary segmentation is also usually transverse, the only exception noted being that represented in the text cut, and there is that general freedom from any fixed order in the subsequent segmentations which Strasburger figures for *Thuja*. Nothing that could be regarded as a true apical cell was observed in any case, for though the form of an apical cell was simulated occasionally, its subsequent history showed that it was a resemblance in form and not in fact, for it never cut off successive oblique segments, or even one.

Figure 5 is contributed by Mr. O. W. Caldwell, and represents the tip of a pollen-tube of *Pinus Laricio* after it has passed through the nucellus and is in the immediate neighborhood of the archegonia. The tip is considerably swollen, as if the protoplasmic contents of the tube are being crowded into it. The four nuclei are plainly seen, as represented by Dixon in *P. silvestris.* Nearest the tip are the two sterile nuclei (C), that of the stalk-cell and that of the tube, which have lost their original outline and evidently have begun to disintegrate. Behind them are the male cells (A and B), usually much more deeply stained than the sterile nuclei, and with B slightly darker than A. The protoplasm about the nuclei contains numerous starch grains, stained red by the erythrosin, as are the two sterile nuclei, and appearing in sharp contrast with the generative nuclei and the wall of the tube, stained blue by cyanin.

Figure 6 is contributed by Mr. W. D. Merrell, and represents a pollen-tube of *Taxus baccata,* which shows an interesting deviation from the description given by Belajeff. The tube has reached and spread out over the top of the endosperm region, in which an archegonium is seen. At an unusual distance up the tube is the large generative cell, not yet divided into the large and small male cells. Above the generative cell lie the consorting stalk-cell nucleus and tube nucleus, whose position is described as invariably in advance of the generative cell. In fact the tube nucleus is normally in advance of the generative cell, and the stalk-cell nucleus soon passes it. Belajeff states that at the very tip of the tube the generative cell divides, and the larger male cells pass into the oosphere, leaving the smaller male cell and the sterile nuclei, now more or less disorganized, stranded in the tube. The preparation figured would indicate that the generative cell sometimes passes in front of the sterile nuclei at an earlier stage than noted by Belajeff. In 6A the general relation of parts is indicated in outline.—JOHN M. COULTER, *University of Chicago.*

MYRIOSTOMA COLIFORME.

AUGUST the 28th, 1896, while on an excursion to Albino Beach, tendered to the Botanical Section of the A. A. A. S. by the Buffalo Naturalist's Field Club, I had the good fortune to find two specimens of *Myriostoma coliforme.* This little fungus is especially interesting in that although very few specimens have been found since it was first recorded, it seems to have a very wide distribution both in Europe and America. Previous to this it had been reported from but two points in North America: first from Colorado by Mr. Peck, and afterwards from Florida by Dr. Underwood.

The specimen which I have answers in nearly every respect to the description given by Mr. A. P. Morgan. It is reflexed and divided into eleven distinct segments; the inner peridium is depressed, slightly globose, being nearly twice as broad as deep; the width is about one inch, and there are eight distinct openings.

The specimen was found in a dense wood, about three hundred yards from the lake shore, and about seventy-five or a hundred feet above the water level.

It was first recorded in Ray's *Synopsis* in 1724; described and figured by Dickinson from Great Britain in 1785; reported from Colorado by Charles H. Peck; collected in Florida by L. M. Underwood in 1891; notes published by A. P. Morgan in *American Naturalist*, April 1892. —MEL T. COOK, *DePauw University, Greencastle, Ind.*

THE COMMON USTILAGO OF MAIZE.

MUCH diversity of usage obtains in writing the name of the common smut of Indian corn (maize). Probably *Ustilago Maydis* Cda. is the form that has been oftenest employed. Since the appearance of Winter's revised edition of Rabenhorst's *Kryptogamen-Flora von Deutschland* in 1881 the form introduced there by the editor, *U. Zeæ-Mays* (DC.) Wint., has been much in favor. The last change to which the purists have given adherence is the form derived by Magnus,[1] and published in 1895. After going over the ground carefully he decided that the name should be *U. Mays-Zeæ* (DC.) Magn.

For some time past the botanical department of the Indiana Experiment Station has been studying some economic features of the smut disease of corn, and incidentally looked into the history of the Latin name of the parasite. As the conclusion attained does not agree with that of previous writers, but brings forward another variation on the name, it is thought best to publish the name adopted and a brief synonymy in advance of the bulletin on the general subject, which is now in course of preparation. The writer's assistant, Mr. William Stuart, is entitled to much credit for carefully going over the accessible literature. He had arrived at the same conclusion as Professor Magnus a short time before the latter's article on the subject appeared. Since then it has been my good fortune to obtain access to other works in the libraries of the British Museum and the University of Bonn, which materially change the result.

[1] Deutsche bot. Monatsschrift 13 : 50.

For some reason not very apparent Winter adopted a name, in other instances as well as in this, which one may assume might have been used by the author cited, but was not. By reference to Lamarck and De Candolle's work, at the place cited by Winter for his name,[2] we find under *Uredo segetum* the hosts mentioned thus: "*In glumis et fructibus hordei, tritici, avenæ, panici miliaci, agrostidis pumilæ, caricis, mays zeæ;*" and on this Winter founded the name. De Candolle does not appear to have ever written "Uredo Zeæ-Mays," as asserted by Winter. There is, however, an earlier name, which conforms to the present usage in regard to the requirement for publication. The name with its principal synonymy may be written as follows:

USTILAGO ZEÆ (*Beckm.*) *Unger.*

1768. *Lycoperdon Zeæ* Beckm. Hannov. Mag. **6**: 1330.
1805. *Uredo segetum Mays-Zeæ* DC. Fl. franç. **2**: 596.
1815. *Uredo Maydis* DC. Fl. franç. **6**: 77.
1825. *Cæoma Zeæ* Lk. Sp. plant. **2**: 2.
1836. *Ustilago Zeæ* Ung. Einfluss des Bodens 211.
1881. *Ustilago Zeæ-Mays* Wint. Krypt.-Fl. **1**: 97.

It is not my purpose to trace the history of the synonyms, but it may be said in passing that Bonnet,[3] Tillet,[4] Aymen,[5] and Imhof[6] do not employ a Latin name for the parasite in their writings, although they are sometimes so quoted. A still earlier work by Planer,[7] occasionally cited in this connection, contains no reference to this disease, or to the fungus, neither does the oft cited work by Tessier[8] on diseases of grain.

Johann Beckmann, the authority for the specific name as given above, was professor of the science of economics at the University of Göttingen, and author of many learned treatises. When Tillet's admirable account of the new and striking disease of maize appeared in the memoirs of the Royal Academy of Paris, he translated the whole article and published it in the *Hannoverisches Magazin*, signing only his initials, "J. B.," on the right side of the page, and the initial of his address, "G.," on the left side. He has in consequence been referred to by the brothers Tulasne and others as an anonymous writer, who signed himself *J. B.*

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[2] Syn. plant. Gall. 47. 1806.

[3] Rech. usag. feuill. 327. 1754.

[4] Acad. Roy. Sci. Hist. **1760**: 85, and Mém. **1760**: 254. Paris, 1766.

[5] Acad. Roy. Sci. Sav. étrang. **3**: 68. Paris, 1760. *Ibid.* **4**: 358. Paris, 1763.

[6] Zeæ maydis morb. ad ust. 1784.

[7] Ustilag. frumenti. Diss. Tübingen, 1709.

[8] Traité mal. grains. Paris, 1783.

Tillet's account of the disease includes a good and unmistakable description of the gross appearance of the fungus, in which he says that its last effect is to convert the excrescence into a black dust, very similar to that which issues from a Lycoperdon, or puff ball.[9] In a footnote to the translation Beckmann has given his opinion that the fungus is a parasitic species of Lycoperdon, and proposes a name in accordance with this view.[10] In assigning it to the genus Lycoperdon he was following the custom of certain good botanists of the day and many years following.[11] To be sure he subsequently decided, upon reading Imhof's researches, that he was mistaken in considering it a parasitic puff ball, and so states in his deservedly popular treatise on German agriculture.[12] Although the author's opinions regarding the relationship of the fungus were not well founded, yet the name was happily and properly conceived and published, and meets the full requirements of present nomenclatural rules.—J. C. ARTHUR, *Lafayette, Ind.*

[9] "Son dernier effet consiste à convertir cette excroissance en une poussière noirâtre et assez semblable à celle qui sort du *lycoperdon* ou *vesse de loupe.*" l. c. 256.

[10] "Meiner Meynung nach, ist das hier beschriebene Gewächs allerdings ein Staubschwamm (*Lycoperdon*) und zwar eine *Species parasitica*, deren in *Lin. Syst. nat.* schon drey befindlich sind, unter welchen also dieser Art, etwa unter dem Namen *Lycoper. zeæ* ein Platz anzuweisen wäre." l. c. 1330.

[11] *Cf.* Schrank, Floræ Salisb., 1792, who places the smut of wheat and oats, and some other equally distantly related fungi under Lycoperdon, along with *L. Bovista*, a true puff ball.

[12] "Einer besondern Krankheit is der Mays in Frankreich und der Schweitz ausgesetzt, da nämlich aus verschiedenen Theilen der Pflanze, vornehmlich auf den Aehren, schadliche auswuchse entstehen, welche ich ehemals für Staubschwämme (*Lycoperdon*) gehalten habe. Aber diese Meinung scheint durch die Beobachtungen widerlegt zu werden, die man in *F. I. Imhof diss. de zeæ maydis morbo ad ustilaginem vulgo relato. Argentorati.* 1784. lieset." Grundsätze der deutschen Landwirthschaft 146. Gottingen, 1790 [ed. 4].—190. 1806 [ed. 6]. The other editions of this work I have not seen.

EDITORIALS.

Equipment for Physiology

IN THE admirable address on Botanical opportunity delivered by Dr. Trelease before the Botanical Society of America, already published in this journal, and also separately distributed, occurs a paragraph on equipment of laboratories for physiological botany which is capable of misapplication. Owing to the expensiveness of such an equipment and the attention required to keep it in order, the suggestion is made that it should be bought in moderation; probably a superfluous suggestion, if one may judge by the condition of American laboratories at the present time. The closing sentence of the paragraph (ante, page 201), however, contains the only point to which exception need be taken. It embodies the old and pernicious idea, very prevalent when laboratories were a novelty, that the pupil, the student, will get the most from his study when he makes for himself the implements and devices needed in his work. The "history of the most successful physiological laboratories," when they are old enough to have passed out of their formative stage, will undoubtedly be that of all the other laboratory sciences. At first instruments are made by the worker, after a time expensive and more or less unsatisfactory instruments are bought, finally good instruments at a reasonable price are obtainable and preferred. "Simple apparatus designed to meet the precise needs of the problem" is a matter of evolution, and at the present day the problem in physiology is often very crudely worked for want of apparatus that has had thought expended upon it, and become the product of the highest mechanical skill.

Tropical Laboratory Commission

IT WILL BE noticed from Professor MacDougal's "open letter" in this number that he accepts, at the suggestion of the GAZETTE, the responsible duty of organizing the commission which shall visit various regions of the American tropics with a view to select a suitable site for a botanical laboratory. The letter also shows that substantial progress has been made, and that the inspection of sites by the commission is assured. The subsequent establishment of the station seems assured by the general sentiment in favor of it. The opportunities offered to American botanists by a conveniently situated tropical laboratory can hardly be overestimated, and the present time seems to be peculiarly appropriate in which to begin the movement. So many things must be considered in this selection that it will be difficult to decide among numerous "favorite sites," but the claims of all should be presented and investigated. The commission must of necessity maintain a judicial mind and express no opinion until its return, but the GAZETTE would suggest that all who have special knowledge of any place which seems to them to be suitable for this purpose should communicate directly with Mr. MacDougal. The assured cooperation of British botanists is a further cause for congratulation. With the general favorable sentiment among botanists, developed by the correspondence of Mr. MacDougal, and with the joint presence of American and British botanists at one or both of the association meetings next summer, it would seem that no small obstacle should stand in the way of seizing the present opportunity.

Foreign Associate Editors

THE PRESENT number of the GAZETTE announces the names of nine foreign associate editors, representing seven European countries and Japan. The names of these botanists are well known in America, and their cordial acceptance of this responsibility promises well for more intimate relations between the botanists of the two hemispheres. It is confidently expected that this association will result in a larger recognition of American work, the lack of which has been pointed out more than once in this journal. These foreign associates are welcomed, not only by the editors of the GAZETTE, but also by American botanists, whom they have put under obligation by offering their assistance in the development of an American journal, and their influence in securing for it the widest possible foreign audience. Their contributions will largely take the form of reviews, notes of current work, and botanical news, so that American botanists will be brought into more immediate contact with foreign botanical activity; while occasional papers dealing with American material will aid in our own problems. It has been the purpose of the editors to secure as associates not only representatives from different countries, but also from different fields of work, that the journal may represent botanical science in its broadest scope.

IT IS NEEDLESS to explain to American botanists the positions and special fields of our foreign associates, as their names are very familiar to all readers of current botanical literature. The list of names and official positions is as follows: PROFESSOR DR. ADOLF ENGLER, Director of the Royal Botanic Garden and Museum, and Professor of Botany in the University of Berlin; DR. FRITZ NOLL, Privatdocent in Plant Physiology in the University of Bonn; DR. H. MARSHALL WARD, F.R.S., F.L.S., Director of the Botanic Garden, and Professor of Botany in the University of Cambridge; DR. LEON GUIGNARD, Professor of Botany at l'École supérieure de Pharmacie, Paris; CASIMIR DE CANDOLLE, Geneva, Switzerland; PROFESSOR DR. JOANNES BAPTISTA DE TONI, Professor of Botany in the Royal University of Padua; DR. EUGEN WARMING, Director of the Botanic Garden, and Professor of Botany in the University of Copenhagen; DR. VEIT BRECHER WITTROCK, Director of the Botanical State-Museum, and of the Botanic Garden and Horticultural School of the Royal Academy of Sciences, Stockholm; DR. JINZŌ MATSUMURA, Director of the Botanic Garden, and Professor of Botany in the Science College of the Imperial University, Tōkyō, Japan.

Mo. Bot. Garden
1897.

OPEN LETTERS.

THE TROPICAL LABORATORY.

To the Editors of the Botanical Gazette.—The desirability and great value of a permanent research laboratory in the American tropics must be evident to every student of plant or animal life. But it should be remembered that a large amount of work has already been done in looking over the ground, and very competent opinion on the subject is already available. Would it not be well to consider first the results already reached? It is well known that parties of zoologists from the Johns Hopkins University, under the lead of Professor W. K. Brooks, have several times visited different parts of the West Indies, including three trips to the island of Jamaica. Their experience has led to the choice of this island as best adapted for a permanent establishment or for periodic visits. A stay of two months in several parts of Jamaica has convinced me that it offers equal advantages for botanical study. It would be an unfortunate mistake to make such an establishment as is proposed exclusively botanical or zoological. Aside from the added strength which the cooperation of both biological groups would give it, the very great mutual advantage of the association must be self evident.

As compared with many other parts of the tropics, the climate of Jamaica is exceptionally healthful, and it is remarkably free from poisonous animals. Its continental character makes possible a rich and varied flora, and within a few miles one may pass from the sea level to the summit of Blue Mountain peak, 7360 feet high. The island is a British colony, which means that life and property are secure, the roads fine, the language English. It is accessible by steamer, at least once a week, from either Boston, New York, Philadelphia, or Baltimore, and the principal points are now connected by railroad. There are on the island two interesting botanic gardens, at Castleton and Gordon Town, under the direction of Mr. Wm. Fawcett, F.L.S., Director of Public Gardens and Plantations, who would doubtless give such an enterprise every encouragement and much valuable aid. Lady Blake, the talented wife of the governor of the colony, Sir Henry Blake, might be expected to be interested in the movement, having several years ago proposed the establishment of an international biological station in Jamaica.

If I may be permitted a definite suggestion as to location, wholly from the standpoint of the botanist, I should say that the north side is far preferable to the south side. And I believe the neighborhood of Port Antonio, which is the chief stopping place of most of the fruit steamers visiting the island, and therefore a very convenient location, offers unsurpassed natural advantages for the study of the flora of both sea and land. By all means let us have the laboratory, but let it be on a broad and solid basis of general cooperation.—J. E. HUMPHREY, *Johns Hopkins University.*

BOTANIC GARDENS.

To the Editors of the Botanical Gazette:— I am glad to see the increased interest manifested in our country for botanic gardens, as their influence for good on all classes of persons is far-reaching. A well equipped university in these days is supplied with library, general museum, herbarium, laboratories, and department of publication. As these institutions are located in or near cities, there is no need for them to duplicate what abounds in the public parks. In the colder portions of the year cultivated plants can be purchased of commercial growers at moderate cost.

The two most common and important defects of many colleges, in the estimation of the botanist, are a botanical museum and a garden in which are grown hardy plants, including trees. If well designed and well kept, these gardens are great attractions to visitors as well as useful to all classes of students.

Universities, colleges, schools of almost every kind, need the use of a botanic garden more and more. As the country becomes older many of the most interesting plants are driven farther and farther back: the roadsides are "slicked up," the odd corners cleared, the wood lot is pastured, the swamps are ditched and burned over. People of all classes are growing up in ignorance of many kinds of wild plants that were once common. In many places people who live in the country are becoming much like those who dwell in the city; both alike crave something which cannot be supplied except by contact with trees, shrubs, grass, weeds, nature clothed in green.

Again, most young people who acquire a love for botany acquire it by coming in contact with nature, especially if accompanied by some skillful guide. Enthusiasm in this direction rarely comes from a study of books alone. Even a garden of small pretensions is of great value, greater than can be understood by those who have tried to rely solely upon the woods and swamps for supplies. It is not costly, and a small start will usually lead to an appreciation by all who see it, and some will assist in securing something better.

With our modern way of sending students to nature for their facts regarding plants, it becomes more and more the habit of teachers to assign certain definite subjects, one or more to each pupil, for essay or thesis. In the writer's experience nothing pleases young or old students better; they all like it. The variety of topics for study in a garden are endless; it may be a study of many kinds of bulbs, rootstocks, runners, insect maneuvers among flowers, the study of eccentric aquatics, bog plants, plant dispersion, modes of spreading, effect of heat and cold, light and shade.

As nearly as practicable all botanists would prefer plants arranged in families, but there may be in addition groups to illustrate certain features of botany, such as medicinal plants; fiber plants; compass plants; sensitive plants; climbing plants; hybrids; modes of distributing seeds and fruits; modes of self-protection by odors, taste, thorns, nettles and the like; a weed garden; a grass garden; a collection of host plants affected by certain interesting fungi, especially those living on two hosts like the rust on barberry and wheat, sedge and nettle, cedar and apple-tree; plants delighting in dry sand; plants holding fruit in winter; a group of plants abundantly clothed with hairs; a group of small evergreens, broad-leaved and pin-leaved; a floral clock; plants indicating fertile soil or barren soil; a group of native plants promising for cultivation for their seeds or fruits; plants of especial use for protecting hillsides and embankments; plants useful for carp ponds; plants poisonous to the touch; plants poisonous to eat; parasitic plants; saprophytic spermatophytes; and the formation of still other groups which will occur to botanists.

The mere horticulturist would discard the natural system of classification in his grouping and run to bedding plants, mixed borders, duplicate patches often arranged symmetrically, and very likely more or less trimmed into artificial form. The engineer would be in danger of running into geometrical figures and grading with terraces. The landscape gardener will plan especially for display, employing a limited number of multiple plats of what he terms the choicest gems of plant growth, neglecting all else. The mere botanist will like a variety, but will most likely lack the tact of the gardener in planting and the management of plants, such as giving each the treatment peculiar to its needs.

Doubtless the greatest success will be attained when the director has in a considerable degree the eye of a botanist, the deft hand of a gardener, the skill of an engineer, the taste of the landscape artist. As he lacks in a marked degree any of these, the garden will fall short of the best that can be done with the means at hand.

Wealthy persons endow astronomical observatories, dormitories, laboratories, libraries, professorships, scholarships, but very rarely think of endowing a botanic garden. Yet as we look at it, what can be more delightful than the thought of having one's name associated with a well kept garden, which shall be a great attraction to thousands of people for the greater part of the year for many years to come. Were there more well kept gardens, doubtless the wealthy would oftener see that they were not wanting for substantial support.

I would not delay the starting of a small garden because I was not ready to maintain a large one. The delay may be long and the garden never appear. As in most kinds of business, there are some good reasons why a botanic garden should start as a small garden. The director must learn some things by experience; no matter how well he may be equipped, the subject will grow as he gives it more thought and as he carries his ideas into execution. To maintain a botanic garden of 1500 hardy plants, excluding most trees and not including the first outlay of the land, will cost not far from fifteen hundred dollars a year in a country place where living is not expensive. In cities it might be two or three times as much. One acre of land would answer very well for 500 kinds of plants, allowing room for paths and small ponds and bogs.—W. J. BEAL, *Agricultural College, Mich.*

THE ACAULESCENT VIOLETS.

To the Editor of the Botanical Gazette.—In the last issue of *Pittonia* I observe that Professor Greene discusses the same group of acaulescent violets of which I published, last spring, the sketch of a proposed revision.[1] I have read with much interest the argument by which he proceeds a step farther in the segregation process, separating *V. cucullata* Ait. from *V. obliqua* Hill. The feature of short-peduncled cleistogamous flowers with hypogaeous fruit, assigned by Professor Greene to *obliqua* in contradistinction to the erect, elongated fruiting peduncles of *cucullata*, may prove a character of some value in separating the species; but from a fairly thorough field knowledge of nearly every phase presented by *obliqua*, I am not prepared to admit that at the proper season specimens cannot be found exhibiting cleistogamous flowers and capsules with peduncles of every possible length, and these all on the same plant. As to the habitat, I think it will be found that the form with leaves of a dark green hue often occurs in open meadows instead of in "somewhat dense, moist thickets," and pale colored specimens are not rare in the shade. In view of the great confusion that has existed among this group of the violets, however, I am quite open to conviction upon this point: and I certainly agree with Professor Greene in the idea that the æstival and autumnal stages of our violets are too much neglected by collectors. Floral characters in this genus are of little value, and we must look to capsule and seeds for permanent specific distinctions.

With respect to the name, *obliqua*, I may say that I was fully aware of the inaccuracies of Hill's plate, against which Professor Greene inveighs so strongly; but I could neither then, nor can I now find any other American violet to which it is in the remotest degree applicable if not to the well known plant under discussion, bearing in mind, of course, the fact that Hill's characterization of "floribus coeruleis" excludes from consideration *V. blanda*, with which Pursh, and *V. rotundifolia*, with which Gray confused it.—CHARLES LOUIS POLLARD, *Washington, D. C.*

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[1] Proc. Biol. Soc. Wash. **10**: 85–92. 1896.

THE TROPICAL LABORATORY COMMISSION.

To the Editors of the Botanical Gazette:—In accordance with your suggestion in the December number of the GAZETTE, I have undertaken the organization of a commission for the selection of a site for an international botanical laboratory in the American tropics. Such universal and substantial interest has been manifested in the matter that the belief is justified that the proposed laboratory is an assured fact and that the cooperation of a majority of the active botanical centers may be depended upon. A consideration of the nature and amount of the work to be done, as well as the conditions of traveling, leads to the conclusion that a commission of not less than three or more than five members would prove the most efficient. It will doubtless be possible to announce the entire personnel in your next issue.

As soon as possible after the organization is completed, a meeting of the American members to perfect plans for the season's work, will be held at some convenient point.

Previously to the organization of the commission, I had been in correspondence with the local botanists and representatives of the governments of the various countries to be visited, and am in receipt of many assurances that a grant of land and other concessions may be obtained without cost in almost any of the places in which the laboratory is likely to be located. This will allow the commission to select a site entirely on its merits as a center for botanical research, and its accessibility.

Any suggestions as to localities to be visited, sent to the undersigned, will be of assistance to the commission in planning the route to be covered.—D. T. MACDOUGAL, *The State University of Minnesota, Minneapolis, Minn.*

CURRENT LITERATURE.

BOOK REVIEWS.

Forestry monographs.

THE APPEARANCE of the first elaborate series of monographs[1] on the valuable timber trees of North America, issued by our division of forestry, deserves more than a passing mention. The large volume before us gives evidence of the untiring zeal and patience of the chief of the division, who has been compelled to fight his way against public sentiment, and scanty appropriations, and difficulty of securing proper observations; and also of the laborious work of his collaborators, in collecting and organizing the mass of facts for presentation.

Historically it may be said that the conception and plan of these monographs dates back ten years, when Mr. Fernow, in his first report (1886), pointed out that the first step to rational forest management was to acquire knowledge of the biology of the valuable timber species, and outlined directions for these studies, which we see has been strictly followed in the present series. Mr. Fernow explained from time to time in his reports why these studies, then begun, have been delayed in publication, the difficulty of securing satisfactory field observations, such as the forester would need, being the principal one.

The five pines considered are *P. palustris* (Long-leaf pine), *P. heterophylla* (Cuban pine), *P. echinata* (Short-leaf pine), *P. Tæda* (Loblolly pine), *P. glabra* (Spruce pine), and their discussion proceeds on botanical, geographic, commercial, and strictly forestal lines. A full synonymy both of botanical and vernacular names, the latter with reference to localities where used, precedes a short statement of the economic importance and historic development of the exploitation of the species, followed by a more or less exhaustive description of the geographical distribution of the same. In this latter the commercial features have been made properly prominent throughout the text, as well as in the maps, but as would be natural to such a botanist as Dr. Mohr, the botanical or plant geographical point of view has never been lost sight of. The characteristics of soil, climate, and flora of the different localities in which the species is found are given in considerable detail, accompanied by measurements of tree development, which enable the forester to form an opinion as to the requirements of the species and its capacity for development under different conditions. Tables of statistics showing the progress of exploitation of the forest resource, together with estimates of standing timber in each locality, enable the student of political economy to form an estimate as to the condition and promise of that resource. A peculiarity of the southern pines is that, although they occur over large areas in pure stands, they do not exhibit the heavy yield per acre so common to the northern pineries. The illustrations of Long-leaf and Cuban pine forests remind one of the open park like character of the forests of the Rocky mountain region more than of the northern pineries. It would appear that the most productive areas, as well as the largest uncut territory of Long-leaf pine, is to be found in Louisiana and Texas, where over 700,000 acres, cutting 6000 feet in the average, are said to exist. The most productive Short-leaf and Loblolly pine areas are also to be found west of the Mississippi, north of the Long-leaf pine area.

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[1] MOHR, CHARLES.—The timber pines of the southern United States. Together with a discussion of the structure of their wood, by Filibert Roth. Bulletin no. 13, Division of Forestry, U. S. Department of Agriculture, pp. 160. 1896.

An interesting botanical point is made in an *addendum* to the Long-leaf monograph, in which Dr. Mohr describes a considerable body of commercial timber of this species in the mountains of Clay county, Alabama, at an elevation of little less than 2000 feet. The most elevated point at which the species had been previously known to exist was 1500 feet.

The botanical descriptions, with developmental features added, are clear and complete, and are accompanied by a series of illustrations which for the most part are excellent examples of the wood engravers' art. They are full of natural sized drawings from nature, with enlargements of single parts. If we should find fault with these plates, thoroughly satisfactory to the student, it would be from the artistic point of view, on account of the inartistic curtailment of the long needles which would not go on the plate, although we are at a loss to suggest how to obviate this trouble and yet preserve the natural size on a 7 × 9 page.

Especial attention has been given to a description of the development of the tree through various stages of its life, and its dependence on surrounding conditions, and this is illustrated by a series of measurements of the rate of growth during the periods of development. This feature is probably one of the most important to the lumberman and forester, as it enables him to base on them profit calculations regarding his forest growth, but it is also of interest to the botanist to know the laws of growth which the species follows through its lifetime. The tables of measurement are accompanied by cleverly devised graphic illustrations, which readily show the varying development during each period of ten years.

The concluding pages are devoted to the study of the structure of the wood of the five pines by Mr. Filibert Roth. Botanists have given comparatively little attention to this subject of wood structure, and Mr. Roth's excellent work, the result of five years' steady handling and studying of these woods in connection with the timber tests of the forestry division, is at once instructive and suggestive. The plates accompanying this part, camera lucida drawings, are clear and thoroughly illustrative. So far no constant distinguishing microscopic features of the species have been found.

The value of the publication is undoubtedly enhanced to the practical man, as well as to the student, by the introduction written by Mr. Fernow. While in part it is a resumé of the contents of the volume in most compact form, it is original and most useful in that it institutes a comparison of four species (Long-leaf, Cuban, Short-leaf, and Loblolly) in their botanical, geographical, and biological features, and the mechanical properties of their wood. In the latter phase the most exhaustive series of investigations instituted in the timber physics section of the forestry division have been the basis. The results certainly open an entirely new field of study of the most practical bearing, which curiously enough has never before been undertaken so systematically. The curves showing the comparative rate of growth in diameter, height, and volume, placed the Cuban pine in all cases as the most rapid, as well as persistent grower; the Long-leaf as the slowest, yet persistent, while the Loblolly, and still more the Short-leaf, decline somewhere near the 100th year. This is an important point for future forestry, since we are informed that the Cuban pine, protected by its rapid height growth from the start, is gradually displacing the Long-leaf in its own area.

NOTES FOR STUDENTS.

THE EXUDATION of gum from grapevine stems has been carefully investigated by Professor E. Ráthay,[1] of the Royal Institution of Enology and Pomology at Klosternenburg near Vienna. He has gone over the literature and studied the malady from the bacteriological, anatomical, and physiological standpoints, and has arrived at the conclusion that the abnormal action is not brought about by bacteria, as asserted by Prillieux, but is due to wound irritation. This irritation induces the formation of tyloses, resulting in the interruption of the continuity of the protoplasm and the premature death of the cells.— J. C. A.

IN A PAPER entitled "Les Hypostomacées, nouvelle Famille de Champignons parasites," Dr. Vuillemin has given an account[2] of two fungi injurious to conifers in France, one of them, which he names *Meria Laricis*, attacking the living leaves of *Larix Europaea*, but producing its fructification after the latter have died and fallen from their attachment; while the second, described as *Hypostomum Flichianum*, occurs on the leaves of species of Pinus. According to the author, the fructification of both these forms originates below the stomata from a structure, compared by him to the ascogonium of the Ascomycetes, that divides into "fertile cells," giving rise in Meria to filaments which produce externally continuous spores borne laterally on short septate ultimate branchlets or directly from the fertile cells. In Hypostomum, on the other hand, the ascogonium-like organ, which is furnished with a "tube ventilateur" or "trichogyne," gives rise to a sporiferous body so similar to that of a Fusarium that the author proposes the name *Fusarium Flichianum* for the use of such skeptics as may prefer this generic designation to Hypostomum. The plants described are considered to afford a link by means of which the Ustilagineæ, Uredineæ, and Ascomycetes are brought into close association. A considerable portion of the paper is devoted to these comparisons, and although one might be inclined to admit that "L'affinité de ce Champignon (Meria) avec les Ascomycetes est aussi solidement fondée que son affinité avec les Ustilaginees," the general conclusions reached would seem to need further corroboration. The text is accompanied by two plates, which suggest that the forms in question may prove to belong to the "Fungi Imperfecti." In connection with his account of the two species mentioned the author also describes a new species of Hendersonia, *H. montana*, on leaves of *Pinus montana*.—D. R.

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[1] Ueber das Auftreten von Gummi in der Rebe und über die "Gommose bacillaire." Wien 1896. Pp. 90, with chart.

[2] Bull. d. l. Soc. d. Sciences de Nancy —: 1–55. 1896.

THE RECENT CONTRIBUTIONS of H. C. Schellenberg to the knowledge of the structure and function of stomata[3] form an important addition to the literature of that subject. After an historical résume of the subject and a statement of the varying anatomical conditions, the author first undertakes to demonstrate, in support of Schwendener, that the guard cells effect the closure of stomata independently of the *Nebenzellen*, to whose influence in this movement he assigns very secondary importance. Several cases are cited in which osmotic pressure, the stomata being closed, is greater in the guard cells than in the *Nebenzellen*, and this condition, it is argued, could not obtain if, as Leitgeb asserts, the latter play the chief rôle in the closure movement. Plants deprived of carbon dioxide were found to have closed stomata, when check plants, other conditions being the same, had stomata open, affording further evidence in support of Schwendener that turgor change in guard cells, and control of stomata thereby, is effected by assimilation. Closed stomata, separated from possible influence of *Nebenzellen*, were opened by turgor artificially induced in guard cells, and reclosed upon exposure to darkness. Measurements of the volume changes of the guard cells show them to be $\frac{4}{10}$–$\frac{5}{10}$ larger when stomata are open than when closed. Stomata in all cases observed were found closed at night, evidence directly contradictory to that offered by Leitgeb and afforded by Stahl's *Cobaltprobe*.[4] The cobalt chloride test for the condition of stomata the author regards as not affording such absolute evidence of stomatic conditions as his own microscopic observation, cuticular transpiration confounding the results obtained by the former means. Finally it is stated that all observations made by the author point toward a return to the conclusions of Schwendener, that the guard cells as independent organs effect the opening and closure of stomata by means of the variations in their osmotic pressure, induced in turn by variation in the activity of assimilation working under the influence of light; and hence stomata are controlled by assimilation, being open in light and closed in darkness, and influencing transpiration *through physical necessity*. Against the conclusion of Leitgeb, that these structures are organs of transpiration rather than assimilation, it is urged that change in illumination is shown to be a much more powerful factor in effecting the stomatic movements than changes in water supply; that evidence of the closure of stomata before apparent wilting is insufficient to prove the case; that stomata closed in darkness cannot be opened by increase of moisture in the atmosphere nor by artificially induced root pressure; and, finally, that stomata are, more than anything else, open when assimilation is most active and closed when darkness diminishes this activity and hence induces flaccidity of chlorophyll-containing guard cells.—J. G. C.

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[3] Beiträge zur Kenntniss von Bau und Function der Spaltoffnungen. Bot. Zeit. **54**: 169–185. 1896.

M. E. D'HUBERT has written an interesting paper[5] upon the embryo sac of fleshy plants. After devoting considerable space to an historical resume of the physiological and morphological problems of reproduction, he gives a detailed account of the ovules of the Cactaceæ, Mesembrianthemaceæ, and Crassulaceæ. In the Cactaceæ the funiculus contains starch, but none is found in the nucleus. Starch appears in the embryo sac at the time of the first division of the nucleus, and increases in quantity as the sac develops. Just before fertilization the synergids, oosphere, and polar nuclei are richly supplied with starch, but the antipodals have lost much of their starch and seem to be degenerating. Fertilization takes place about three weeks after pollination. During this period the antipodals disappear completely, and the synergids lose some of their starch, but the nutrition of the sac proceeds actively, and a great quantity of starch accumulates around the polar nuclei, which are very late in fusing. When the pollen tube reaches the sac, the nucleus of one synergid advances to meet the nucleus of the tube, while the nucleus of the other synergid moves toward the nucleus of the oosphere. The polar nuclei now fuse, and the resulting nucleus

[4] Einige Versuche über Transpiration und Assimilation. Bot. Zeit. **52**: 117–146. 1894.

[5] Recherches sur le Sac embryonnaire des Plantes grasses. Ann. Sci. Na Bot. VIII. **2**: 137–28, *plate 1–3*. 1895.

almost immediately divides, so that there are four or five nuclei in the endosperm when the fusion of sex-cells takes place. As the endosperm develops the starch disappears. The pollen tube contains starch as it passes through the style, but not at the time of fertilization. The author claims that the state of the reserves forms a basis for determining the functions of the various cells of the embryo sac, and concludes that the antipodals nourish the sac before fertilization, the synergids give nutrition to the nucleus of the pollen tube and the nucleus of the oospore at the time of its formation, and the polar nuclei nourish the egg and give rise to the endosperm.

The ovules of the Mesembrianthemaceæ and Crassulaceæ showed the same starch reserve. Many other forms were studied, both in monocotyls and dicotyls, and the author's conclusion is that all fleshy plants have starch in the embryo sac. Some non-fleshy plants exhibit in a feeble degree this character, which is general for fleshy plants. The author thinks that there is some connection between the starch reserve and the slowness of the phenomena which precede fertilization.—C. J. C.

MR. D. T. MACDOUGAL[6] has been investigating the relation of the growth of foliage leaves and the chlorophyll function. The main purpose of the investigations was to determine the extent to which leaves are dependent upon food supplies constructed within their own tissues, and to what extent development may proceed at the expense of food stored in neighboring or organically connected members. The species used in his work were *Arisæma triphyllum*, *Calla palustris*, *Hibiscus Rosa-sinensis*, *Isopyrum biternatum*, *Justicia* sp., *Lilium tigrinum*, *Oxalis floribunda*, *O vespertilionis*, *Phœnix dactylifera*, *Trillium erectum*, *T. erythrocarpum*, and *Zea Mays*. In general, they were all studied as to the effect of an atmosphere free from CO_2, and the effect of darkness. It was made evident that the leaves of different species exhibit individual reactions to an atmosphere free from CO_2. The author divides the existence of a leaf into three periods, viz., (1) from the rudimentary condition to the unfolding of the lamina, (2) the unfolding and expansion of the lamina to such an extent as to attain a normal stature, and (3) the existence of the organ after maturity has been reached. During the first period the leaves develop without regard to the amount of CO_2 in the air. During the second period the greatest amount of divergence occurs, the leaves of some plants perishing quickly in an atmosphere free from CO_2, others developing more or less completely before perishing, others attaining a size less than normal and then continuing to lead a healthy life, and others developing in a normal way. The behavior of leaves in an atmosphere free from CO_2 and in darkness exhibits the greatest divergences. Thus, leaves of Mimosa and Phaseolus may attain normal size in darkness but quickly perish in air free from CO_2, while in Isopyrum and Oxalis exactly the reverse is true. The following conclusions are also sustained: (1) material constructed in active chlorophyll areas and stored in special organs may be transported to inactive chlorophyll bearing organs in some plants in light and in darkness, and used in such manner as to allow of the perfect development of these organs; (2) the removal of concurrent members in darkness may have no effect, may cause an exaggerated development of the petioles, or may result in the perfect development of the entire leaf; (3) it is possible for some plants to form perfect leaves in darkness, some when a portion of the stem only is darkened, and others when the entire plant is etiolated, thus showing that no invariable connection exists between the phototonic condition and leaf development; (4) the conclusion of Jost, that pathological conditions ensue more quickly in inactive leaves in light than in darkness, is not capable of general application; (5) placing a leaf under such conditions that it cannot construct food material sets in motion the specific regulatory mechanism of the organism in such a manner that the plastic material may be withdrawn and the organ cast off; (6) it is to be noted that plants may not be classified upon the basis of species entirely as to their reaction to an atmosphere free from CO_2, since a given plant may be capable of developing inactive leaves at one stage of its development, and not at another.— J. M. C.

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[6] Jour. Linn. Soc. **31**: 526–546. 1896.

THE GASES produced by certain bacteria when grown in 2 per cent. sugar bouillon have been studied by L. H. Pammel and Emma Pammel,[7] of the Iowa Agricultural College, using Theobald Smith's fermentation tube. Five species were fully studied, of which a micrococcus from cheddar cheese gave no gas. The production of hydrogen and carbon dioxide from the other species was as follows:

Species	Source	Glucose		Saccharose		Lactose	
		% H	% CO_2	% H	% CO_2	% H	% CO_2
Bacillus aromaticus	Rotting cabbage	73.6	26.36	77.2	22.8	0	0
B. gasoformans	Imperfectly sterilized gelatin	77.25	10.65	56.45	43.5	0	0
B. mesentericus vulgatus	Imperfectly sterilized potato	0	0	37.05	63.4	74.5	25.4
B. coli communis	....	75.8	24.18	66.0	32.9	71.05	28.0

Morphologic and ecologic data are also recorded.— J. C. A.

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[7] Centralblatt für Bak. u. Par. II. **2**: 633–650. *pl.* 5. 1896.

Mr. John Klercker has published a very interesting paper[8] upon the polymorphism of some lower forms of algæ, speaking chiefly of *Stichococcus subtilis* and *S. bacillaris*. These forms are found to exist either as isolated cells or as filaments. Great variation is shown in both species as to the dimensions of the cells, size of the chloroplasts, and behavior of the forms in different culture media. The old taxonomy called the unicellular forms *Stichococcuss ubtilis* and *S. bacillaris*, while the filamentous forms were known as *Ulothrix subtilis* and *U. flaccida*, respectively. These seem to be nothing more than different phases of the same thing, if it be conceded that the filamentous forms of Stichococcus warrant their association with Ulothrix filaments. The author states that no starch grains are formed in *S. subtilis*.—O. W. C.

In his recent revision[9] of the genus *Silene* Mr. Frederic N. Williams recognizes nine genera in the subtribe Silenoideæ, viz., Agrostemma, Lychnis, Coronaria, Petrocoptis, Heliosperma, and Melandryum, with one-celled capsules; and Viscaria, Eudianthe, and Silene, with capsule plurilocular at base. This treatment refers many North American species to Melandryum which have been described under Silene, as *S. Bernardina*, *Lemmonii*, *montana*, *occidentalis*, *Oregana*, *Palmeri*, *Parishii*, *platyota*, *plicata*, *Shockleyi*, *Thurberi*, all of Watson, *S. Drummondi* Hook., *S. longistylis* Engelm., *S. simulans* Greene, and *S. subciliata* Robinson. Thus restricted, 390 species of Silene are recognized, but twenty-five of which are natives of North America. The author is to be congratulated that in the revision of so large and perplexing a genus he has found it necessary to describe but five new species. The synonymy of three North American species may be noted. *S. verecunda* Watson is *S. Behrii* Williams; *S. incompta* Gray (*S. multicaulis* Durand) is *S. Bridgesii* Rohrb.; *S. Scouleri* Hook. contains *S. Drummondii* Gray, *S. Hallii* Watson, and *S. purpurata* Greene.—J. M. C.

At a recent meeting of the German Academy of Science and Arts at Frankfort, Professor O. Drude presented a contribution on the taxonomy of Umbelliferæ, which is briefly and somewhat unsatisfactorily reported.[10] As he is known to have had this difficult group in hand for several years for presentation in Engler and Prantl's *Naturlichen Pflanzenfamilien* no small degree of interest is felt in reference to his conclusions. The report from which this statement is made is rather indefinite, but probably indicates the larger outlines with sufficient clearness. The family is thought to present three great divisions, Hydrocotylinæ, Saniculinæ, and Apioinæ. The first division is characterized by the absence of oil tubes and the formation of a hard fruit, the woody endocarp containing an abundance of crystal bearing cells. Coriander, belonging to the third group, also has a woody endocarp but lacks the crystal bearing cells. The Saniculinæ do not possess a characteristic fruit, and the oil tubes are either wanting or they replace the fibrovascular bundles. The Apioinæ constitute the large and very perplexing group of the family, and are broken up into eight tribes. The intricate relationships of these eight tribes are presented, the Scandicineæ apparently being related to the Saniculinæ through Echinophora and Arctopus. The Scandicineæ in turn are represented as having three lines of relationship connecting them with all the other tribes of Apioinæ. One of these lines leads to the Ammineæ, which in turn are connected through the Seseleæ and Peucedanum with the Peucedaneæ. Another line connects Scandicineæ with Daucineæ, through Caucalineæ, and Daucineæ in turn are connected with Thapsieæ. The third line connects Scandicineæ with Smyrnieæ, which in turn lead to Coriandræ. It should be said that these statements are derived from a complex schematic presentation without any explanatory text, and that so far as numbers and type indicate the eight tribes of Apioinæ are Echinophora, Scandicineæ, Coriandræ, Smyrnieæ, Ammineæ, Peucedaneæ, Thapsieæ, and Daucineæ, although the inconsistent terminology does not indicate correlative groups.— J. M. C.

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[8] Flora **82**: 90–106, *pl.* 6. 1896.

[9] Jour. Linn. Soc. **32**: 1–196. 1896.

[10] Bot. Central. **68**: 211. 1896.

AN IMPORTANT CONTRIBUTION to our knowledge of the affinities and development of the Phalleæ, as illustrated by the successive stages of *Mutinus caninus*, is based upon Professor Burt's study[11] of an essentially complete series of the eggs of this species (the smallest of which measured not more than $\frac{1}{3} \times \frac{2}{3}^{\mathrm{mm}}$), including conditions not hitherto critically examined by students of the group, and furnishing evidence of crucial importance in connection with the consideration of phylogenetic relationships between the Phalleæ and the Clathreæ. The structure and development of the form in question were studied by means of microtome sections, excellent figures of which accompany the text, and seem to afford important data in support of the author's view, recently more fully elaborated in his paper on *Clathrus columnatus*, according to which the Phalleæ are regarded not as an offshoot from the Clathreæ, but as constituting an independent and parallel series not directly related to them.—R. T.

J. G. AGARDH, in the third fascicle of his very important *Analecta Algologica*,[12] describes the following species which are new to science and to the American flora: 1. *Phylittis tenuissima*, Florida (*Curtiss*); 2. *Endarachne Binghamiæ* (a new genus near Scytosiphon), California (*Bingham*); 3. *Cystoseira Myrica occidentalis* (*C. Myrica* Palm. Ag. Baham. no. 8), Florida and the Bermuda islands; 4. *Hooperia Baileyana* (Harv.), a genus established upon the *Chylocladia Baileyana* described by Harvey in his *Nereis Boreali Americana* 185, *pl. 80;* 5. *Diplocystis Browneæ* (*Callophyllis Browneæ* J. Ag. Bidr. Alg. Syst. **4**: 36), West Indies (*Curtiss*); 6. *Liagora opposita*, Florida; 7. *L. tenuis*, Florida; 8. *L. corymbosa*, Florida and the Bermuda islands; 9. *L. paniculata*, West Indies (*Curtiss*). On account of the homonymous genus Diplocystis proposed by Berkeley and Curtiss (*Cuban Fungi* 344; *cf.* De Toni in Saccardo Syll. Fung. 7^1: 92), it is necessary to change the name given by Agardh and to use **Agardhinula** mihi.—DE TONI.

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[11] Annals of Botany 10: 343. 1896.

[12] Acta Soc. Reg. physiograph. Lundensis 7: —. 1896.

ITEMS OF TAXONIC INTEREST are as follows: In the continuation of his work upon *Potentilla* Rydberg describes[13] three new species, *P. ramulosa* from Arizona, *P. bicrenata* from Colorado and New Mexico, and *P. millefolia* from California. Davenport has given a full account,[14] with Faxon's illustrations, of his new *Aspidium simulatum*, published in this journal.[15] Mr. Henry Ridley has published[16] an account of the Orchidaceæ, Apostaciaceæ, and Cyrtandraceæ of the Malay peninsula. Eighty-seven genera of orchids are represented, fifteen of which are confined to the Malay peninsula and archipelago, and four of which are described as new, Staurochilus, Renantherella, Pelatantheria, Ascochilus. The genus Dendrobium is the largest, being represented by seventy-eight species. No less than 130 new species of orchids are described, and about thirty-five new species of Cyrtandraceæ. Mr. R. Allen Rolfe has published[17] a revision of the genus Vanilla. It is widely diffused throughout the forest region of the tropics, but the species are very local. Fifty species are known, and of these twenty-nine are American, eleven Asiatic, and ten African. The greatest display of the genus is in Brazil and Guiana. H. Christ has described[18] numerous new species of ferns from Costa Rica. Professor E. L. Greene has issued another fascicle[19] of new species belonging to the following genera: Crepis (4 spp.), Allocarya (3 spp.), Oreocarya (9 spp.). M. C. De Candolle has published[20] an enumeration of the Begoniaceæ of Costa Rica, the genus Begonia containing twenty species, five of which are described as new. Dr. F. W. Klatt has published[21] a second fascicle of the Compositæ of Costa Rica, the first being published in the same journal in 1892. The present contribution adds thirteen new species. A recent contribution[22] from the Gray Herbarium by Dr. B. L. Robinson and Mr. J. M. Greenman contains the following subjects: a revision of the genus Tridax, containing twenty-two species, three of which are new; a synopsis of the Mexican and Central American species of the genus Mikania, containing thirteen species; a revision of the genus Zinnia, containing sixteen species, two of which are new; a revision of the Mexican and Central American species of the genus Calea, containing twenty-eight species, five of which are new; a provisional key to the species of Porophyllum north of the Isthmus of Panama, containing twenty-six species, three of which are new; descriptions of new and little known phanerogams, chiefly from Oaxaca, the new species belonging to the genera Habenaria, Spiranthes, Cranichis, Microstylis (2 spp.), Phoradendron, Euphorbia (3 spp.), Cardiospermum, Erythræa, Nama (2 spp.), Berendtia, Castilleia, Carlowrightia (2 spp.), Oldenlandia, Eupatorium (2 spp.), Chrysopsis, Bigelowia, Lagascea, Trigonospermum, Montanoa (2 spp.), Viguiera, Verbesina (4 spp.), Dahlia, Flaveria, Liabum, Senecio, Gochnatia, Perezia (2 spp.). The current bulletin[23] from the natural history departments of the University of Iowa contains the following botanical papers: the puff balls of eastern Iowa, by T. H. MacBride and Norra Allin; new species of tropical fungi, by Ellis and Everhart, fourteen in number, and chiefly from Nicaragua; and the Nicaraguan myxomycetes, by T. H. MacBride and C. L. Smith. The current parts (140 and 141) of Engler and Prantl's *Natürlichen Pflanzenfamilien* contain the continuation of Labiatæ, by J. Briquet, in which Calamintha is merged under Satureia, and Pycnanthemum becomes Koellia; and the completion of the Fucaceæ, by F. R. Kjellman, and the beginning of Rhodophyceæ, by Fr. Schmitz and P. Hauptfleisch.—J. M. C.

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[13] Bull. Torr. Bot. Club, **23**: 429. 1896.

[14] Garden and Forest **9**: 484. 1896.

[15] BOT. GAZ. **19**: 495. 1894.

[16] Jour. Linn. Soc. **32**: 213–416, 497–528. 1896.

[17] Jour. Linn. Soc. **32**: 439–478. 1896.

[18] Bulletin l'Herb. Boiss. **4**: 657–663. 1896. Bull. Soc. Roy. Bot. Belg. **35**: 107–249. 1896.

[19] Pittonia **3**: 107–114. 1896.

[20] Bull. Soc. Roy. Bot. Belg. **35**: 256–267. 1896.

[21] Bull. Soc. Roy. Bot. Belg. **35**: 277–296. 1896.

HANSGIRG recognizes[24] four types of flowers whose protection of their pollen against rain belongs to the realm of phytodynamics. (1) Plants whose flowers close in rainy weather, so that the entrance of rain drops is rendered difficult or impossible, while the flowers or capitula, seated upon a rigid stalk not capable of rain-avoiding curvatures, do not change their position. (2) Plants whose flowers at anthesis upon flexible erect straight pedicels have their opening zenithward, but at the approach of rainy weather, without closing the perianth, protect their pollen, nectar, etc., against wetting by special rain-avoiding curvatures of their pedicels. (3) Plants whose inflorescences seek to protect themselves against rain by special curvatures of the axis of inflorescence or of the axis carrying the capitula, umbels, etc., especially of the terminal part where the flowers are in anthesis. (4) Plants whose flowers, erect and open in fine weather, upon the approach of rainy weather not only close the perianth, but also turn the flower away from the source of the rain drops by curvatures of the pedicels or axes.— C. R. B.

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[22] Proc. Amer. Acad. 32: 1–51. 1896.

[23] Bull. Lab. Nat. Hist. Univ. Iowa 4: 1–90. 1896.

[24] Uebersicht der vier Typen von regenscheuen Blüten, deren Pollenschutz, etc., auf phytodynamischen Principe beruht. Œsterr. bot. Zeits. 46: 357. O. 1896.

THE USTILAGINEÆ of Kansas have been listed and their germination in part studied by Mr. J. B. S. Norton.[25] Thirty-three species are given, of which two are described as new, viz., *Ustilago filifera* on Bouteloua racemosa and B. oligostachya, and *U. minor* on B. hirsuta. The previously known species on B. oligostachya (*U. Boutelouæ* Kell. and Swing.) was studied and compared with the new kinds. The germination of nineteen species was attempted, and with success in the case of fourteen. The characteristic results of the germination are shown upon five plates.— J. C. A.

IN A RECENT paper[26] Professor L. F. Ward treats of some analogies in the lower Cretaceous of Europe and America. Among the various subjects considered, the occurrence of ancestral forms of angiosperms in the Jurassic and lower Cretaceous, and the distribution of fossil cycad forests are of special interest to botanists. In America fine collections of lower Cretaceous cycadean trunks have been found in the Black Hills of South Dakota, in beds probably belonging to the Kootanie, and in the Potomac formation of Maryland. During his recent visit in Europe, Professor Ward found a collection of twenty-one cycadean trunks, which had been obtained from the Purbeck beds of the Isle of Portland, where the specimens described by Buckland in 1828 were obtained. These specimens, which have been purchased by the United States National Museum, are small and dwarfish when compared with the American forms from Maryland and the Black Hills. A fossil cycad trunk has also been found in the Scaly clays of the Province of Bologna, Italy. The Scaly clays are undoubtedly lower Cretaceous, and it is probable that all the numerous cycad trunks found in Italy were derived originally from these Scaly clays. From a consideration of these facts, it seems that cycads of the tuberous stem type were of very wide distribution in the temperate zone during lower Cretaceous times.

Before 1888 no dicotyledonous plants had been known from any deposits older than the Cenomanian, with the single exception of Heer's *Populus primæva* from the Kome beds (Urgonian) of Greenland. It was supposed, therefore, that the present dominant vegetation had its origin in the middle Cretaceous. Fontaine, while working on the fossil plants of the Potomac formation, found that the great majority were ferns, cycads, and conifers; yet there were certain obscure forms, represented by broad expansions resembling fronds or leaves, with coarse reticulate nervation, which he was unable to refer to these groups. He thought they might represent peculiar dicotyledonous leaves. At the same time that Fontaine was working at the Potomac flora, Saporta was studying the lower Cretaceous of Portugal. He found some true dicotyledons, but other forms he established under a special division which he named proangiosperms. One of the important genera referable to this group is Protorhipis of Andrae, founded in 1853 upon a remarkable form from the Lias of Hungary. This specimen was named *P. Buchii*, and was considered to be a fern. In the meantime other species were described: *P. asarifolia* Zigno, from the Oolite of Italy; *P. integrifolia* Nath., and *P. crenata* Nath., from the Rhetic of Sweden; *P. reniformis* Heer, from the Oolite of Siberia; *P. cordata* Heer, from the Urgonian of Greenland; and *P. Choffati* Sap., from the Urgonian of Portugal. Saporta has reviewed all of these species and concludes that they do not belong to the ferns, but are truly archetypal angiosperms. Four other genera, Changarniera, Yuccites, Delgadopsis, and Eolirion, are put in the group proangiosperms. These last four genera are considered to be ancestral monocotyledons. Saporta, however, hesitates to class *Protorhipis Buchii*, *P. integrifolia* and *P. crenata* with his proangiosperms, since they lack the distinction of midrib and secondary nerves, although they closely resemble certain dicotyledonous leaves and are comparable in nervation with Credneria and some fossil viburnums. Certain Potomac forms referred by Fontaine to Menispermites, Hederæphyllum, Proteæphyllum, and Populophyllum, have some resemblance to *Protorhipis Choffati* through their areolate nervation, and no doubt represent ancestral types of angiosperms.

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[25] Trans. St. Louis Acad. Science **7**: 220–241. *pl. 25–29.* 1896.

[26] Ann. Report U. S. Geol. Surv. **16**: 463–540. 1896.

Thus the true angiosperms have been traced far below the middle Cretaceous, the Jurassic of Portugal alone containing eight monocotyledons and one proangiosperm; and if the forms classed as proangiosperms are truly the forerunners of both the monocotyledons and dicotyledons, as Saporta considers them, we have an apparent fern origin for the angiosperms.—
—J. H. S.

DR. HERBERT M. RICHARDS, of Barnard College, has published[27] an account of the development of aecidia upon several hosts, Peltandra, Houstonia, Ranunculus, Anemone, and Sambucus. The work was undertaken with the purpose of determining with greater definiteness the origin of the basidia and the structure and development of the peridium. It seems that the basidia arise from certain hyphae, called fertile hyphae, situated in the midst of the primordium or pseudo-parenchymatous mass of mycelium, which indicates the beginnings of an aecidium. The fertile hyphae are simply modified vegetative hyphae, somewhat larger and richer in granular protoplasm than their neighbors. They may be somewhat twisted, suggesting the appearance of a Woronin's hypha, but nothing was discovered that could be directly homologized with an archicarp.

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[27] On some points in the development of aecidia. Proc. Amer. Acad. 31: 255. 1896.

The basidia bud out from the fertile hyphae, and new basidia are formed mainly at the periphery, but some younger ones may later be intercalated between the old. Sometimes the fertile hyphae branch to a considerable extent (aecidium on Ranunculus), and it is probable that there is present more than one fertile hypha in large aecidia. The fertile hyphae in the aecidia on Peltandra and Houstonia branch very little. Spores are formed after the manner described by Rosen. The sterile interstitial cell is cut off from the lower portion of the spore mother cell. In many cases the spores contain a triple nucleus in place of the usual double nucleus. The peridium appears to result from the metamorphosis of the outer layer of spores or spore mother cells. In the aecidium on Sambucus there are even present at first the interstitial cells, but these soon disappear with the enlarging of the peridial cells and the thickening of their walls.—B. M. D.

MINOR NOTICES.

THE INDIANA ACADEMY of Sciences has been a strong and active society from its organization in 1885. In March 1895 the state assumed the expense of the publication of its proceedings, three volumes having previously been printed by the society. The proceedings for 1894 and 1895 have been printed in accordance with the state law, and put into the hands of the state librarian, who has only recently distributed them for lack of funds to cover postage. The volume for 1895 contains 298 pages and many well printed illustrations. Its articles embrace a wide range of subjects and are of high merit. The principal botanical papers are as follows: Wm. Stuart describes experiments which reduced the smut of corn from 13 per cent. to 3 per cent. by using Bordeaux mixture, and to 6 per cent. by using ammoniacal copper carbonate; Severance Burrage gives a new station (Lafayette, Ind.) for *Pleodorina Californica*, with notes upon some features of its occurrence; Stanley Coulter reports upon noteworthy Indiana phanerogams and upon some special collections as part of the state biological survey, which has been under way for three years; Alida Cunningham also contributes to the survey an account of the distribution in the state of thirty-seven species of Orchidaceae. There are shorter articles or notes upon the circulation of protoplasm in Chara by D. W. Dennis, microscopic changes in the shrinkage of woods by M. J. Golden, microscopic slides as adjuncts to an herbarium by John S. Wright, and forms of *Xanthium Canadense* and *X. strumarium* by J. C. Arthur. There is an extended report upon a biological survey of Turkey lake, from which one misses an account of the aquatic or plankton flora, with the exception of a note on the occurrence of a Rivularia in quantity to form *Wasserbluthe*, and of a Palmella that replaces it in a similar way in late autumn.—J. C. A.

Dr. B. L. Robinson and Mr. H. von Schrenk have published[28] an interesting account of their botanical exploration of Newfoundland during the summer of 1894. It is strange that this very accessible and interesting region has been visited so seldom by botanists, the spermatophyte flora being scarcely represented in the best herbaria of Europe and America, and in none better than by fragmentary sets of Banks and LaPylaie. The visit was made to secure a number of uniform sets for distribution and to lay the foundation of a fuller knowledge of the flora. Some twenty sets were secured, containing 381 numbers of spermatophytes and pteridophytes, 123 of which have not been recorded hitherto from Newfoundland.—J. M. C.

A PUBLICATION of more than usual interest has just been issued from the Boissier herbarium. Under the title *Hortus Boissierianus* Mr. Eugéne Autran, curator of the herbarium, and M. Théophile Durand, curator of the botanic garden at Brussels, have published a volume of nearly 600 pages containing an enumeration of the plants cultivated in 1885 by Boissier, the year of his death, in the gardens at Valleyres and Chambésy, specimens from which have enriched many collections. Possessed of an ample fortune and large experience, M. Boissier brought together a most remarkable collection of living plants, containing many specific types. This great collection has been preserved with the greatest care, and today presents unusual facilities for botanical study. The wealth of living material thus brought to notice cannot fail to attract the interest and attention of botanists. The volume is not a bare enumeration of the nearly 5000 species, but includes synonymy, ample bibliography, which is especially useful in its references to good plates, and geographical distribution. The careful establishment of 5000 specific names is a great task, and we anticipate that *Hortus Boissierianus* will become almost as familiar in taxonomic references as *Hortus Cliffortianus, Hortus Kewensis,* etc. A summary of the enumeration shows 2524 species of dicotyledons, 1748 monocotyledons, 77 gymnosperms, and 346 pteridophytes, besides 359 well marked varieties. An interesting preface is written by M. F. Crépin, the director of the botanic garden at Brussels. —J. M. C.

Dr. Veit Wittrock has published the result of his studies upon the history and origin of pansies.[29] The wild pansy, *V. tricolor* L., was first mentioned by Brunfels in 1536, at which time it was found not only wild but cultivated for ornament in the gardens of Germany. The name "pansy" was first used in botanical literature by the Frenchman Ruellius, in 1537. Although used as an ornamental plant during the sixteenth, seventeenth, and eighteenth centuries, the forms were properly wild pansies, and it is only in the present century that the numerous varieties of garden pansies have been produced. The pansies of the present day are originally natives of England, where during the first years of the present century much attention began to be paid to pansy cultivation. From that time on the progress has been very rapid. Dr. Wittrock concludes that the pansies of the present day form an aggregate of very different forms of plants produced by hybridization between various species of the genus. The original stock is *V. tricolor*, but several other kindred species have been grafted thereon, and one of them, *V. lutea* Huds., to such a degree that it has probably a larger share in the production of the pansies of the present day than *V. tricolor*. From this point of view, the cultivated pansy cannot be included exactly under the idea of species or variety as used by taxonomists. Comparison of cultivated forms with their wild ancestors shows that the most conspicuous change is that the transverse diameter of the flower has become about the same as its longitudinal diameter, brought about by an excessive development chiefly of the middle petals. As regards the spur, pansies generally follow the short-spurred parent species, *V. tricolor*, *V. lutea*, and *V. altaica*. The few long-spurred pansies show their descent from such species as *V. cornuta* and *V. calcarata*. In coloration the cultivated forms show a far greater variation than all the parent species, scarcely a color or shade being unrepresented excepting green, even pure blue and pure red having been obtained, the most difficult colors to produce. Whatever the variety of color may be, the "eye," that part of the lowest petal which is immediately in front of the entrance to the spur, is always bright yellow. The author, regarding this as closely associated with pollination by insects, considers it as indicating such a degree of resistance to all conditions that it will give way to nothing. The same fixity of color is found in the spur, at least towards its tip, which is always some shade of violet no matter what permutations of color may be displayed by the flower in general. The significance of this is not suggested, and if the pollinating insects prove to be color blind, as is claimed now by physiologists, the yellow eye, as well as all floral coloration, will need a new explanation.—J. M. C.

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[28] Robinson, B. L. and Schrenk, H. von.—Notes upon the Flora of Newfoundland. Reprinted from the Canadian Record of Science, January and April 1896.

[29] Acta Horti Bergiani **2**: no. 7. 1896.

NEWS.

PROFESSOR DR. FR. SACCARDO, of the Avellino School of Viticulture and Enology, died recently in Avellino, South Italy.

THE GOVERNMENT of Dutch India has appropriated $6000 for the erection of a research laboratory at the Buitenzorg garden.

MR. C. G. PRINGLE has returned from his annual trip into the more unknown regions of Mexico, with about 20,000 specimens.

MISS MARY A. NICHOLS, who received the degree of Sc.D. at Cornell last June, is carrying on special studies in the herbarium of Columbia University in connection with her work in teaching in New York City.

DR. ALEXANDER P. ANDERSON, who has been completing some research work at the Missouri Botanical Garden, has been appointed Professor of Botany at Clemson College, South Carolina, having entered upon his duties January 1.

MR. M. A. HOWE, formerly instructor in the University of California, is engaged in graduate work at the Columbia University. He is working up the bryophytes of California, having made very extensive collections during his residence there.

ACCORDING TO Wildeman, the known alga flora of Belgium, including both marine and fresh water forms, contains 1179 species, distributed as follows: Chlorophyceæ (incl. Characeæ) 387, Diatomaceæ 613, Phaeophyceæ 51, Florideæ 78, Cyanophyceæ 50.

M. L. GUIGNARD, as the representative of the Academy of Sciences, gave a brief address at the funeral of M. Trécul, which is printed in *Jour. de Botanique* (Nov. 1). It is very brief, but full of interesting information concerning the botanist and the man.

MR. E. G. LODEMAN, instructor in horticulture in Cornell University, a scientific horticulturist of great promise, and author of *The spraying of plants*, one of Macmillan's Rural Science Series, died by his own hand December 2, at Mexico, N. Y., during an acute attack of melancholia.

MR. E. O. WOOTON, recently professor of botany in the Agricultural College of New Mexico, is a graduate student at Columbia University, and is engaged in a special study of the flora of New Mexico, having made extensive collections in that territory during his five years' residence there. He is expecting to spend considerable time during next summer in additional field work in that region.

Dr. B. D. Halsted has printed a syllabus of six extension lectures upon the subject of fungous diseases of cultivated plants. As the selection of subjects for such courses is sometimes a puzzling question it is of interest to know that the subjects of this syllabus are Fungi injurious to (1) field and root crops, (2) orchard crops, (3) small fruits, (4) vegetable fruits, (5) vegetables, (6) ornamental plants.

Professor Koch, by direction of the German government, has gone to South Africa to investigate the rinderpest, an exceedingly contagious disease affecting cattle. An investigation of this disease was made in 1868 by the British, but no result of scientific value was obtained. With the far better bacteriological methods of today it is to be hoped that Professor Koch may obtain more definite results.

Mr. John C. Willie, who has succeeded the late Dr. Trimen as Director of the Royal Botanic Gardens at Peradeniya, Ceylon, is desirous of developing scientific research in connection with his laboratory. The gardens are very large, and the flora is as rich and probably less "worked" than that at Buitenzorg. Mr. Willie hopes to call the favorable attention of students to the advantages offered by Peradeniya.

At the meeting of the Academy of Science of St. Louis, held December 21, 1896, Mr. H. von Schrenk made some remarks upon the parasitism of lichens, illustrated especially by the long hanging forms of *Usnea barbata*, common on Juniperus, etc., on Long Island, N. Y. It was shown that these lichens do not penetrate below the outer periderm of the host, and consequently are not to be regarded as true parasites, but that they frequently cause the death of the latter by suffocation. As Schimper has noted for the long moss of the south, *Tillandsia usneoides*, the plant is capable of dissemination by wind and birds, and of growing in new stations without attachment

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BOTANICAL GAZETTE

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THE

BOTANICAL GAZETTE

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VOLUME XXIII NUMBER 2

BOTANICAL GAZETTE

FEBRUARY 1897

OPPORTUNITIES FOR RESEARCH IN BOTANY OFFERED BY AMERICAN INSTITUTIONS.

ELEVEN years ago the GAZETTE published what was called a "laboratory number," in which were described the facilities of some of the institutions which had equipped laboratories for instruction in elementary botany. Within the last decade a considerable number have not only provided for elementary work but also for the advanced work and research leading to a doctor's degree.

In conversation with two of the editors of the GAZETTE last summer, Professor MacDougal suggested that it would be of advantage to botanists for the editors to bring together a statement of the opportunities for research now afforded by American laboratories. To present an absolutely complete statement of this kind is obviously an almost impossible task, since there is no sharp line between research in pure and applied botany, and there are many advantages for original research in connection with the agricultural experiment stations. It seemed best, therefore, to limit the present account to the institutions conferring a doctor's degree. This excludes such important institutions as the National Herbarium, the Missouri Botanic Garden, and others, whose extensive libraries and collections are freely open to all qualified students.

The degree Ph.D., or Sc.D., is conferred by the institutions represented in the following pages only in recognition of capacity for original research as shown by a thesis approved by the faculty. A residence of at least one year, and in some cases two years, at the university conferring the degree is required. Upon the presentation of a satisfactory thesis the candidate is admitted to examination, which must show familiarity with the general subject of botany, and in most institutions with one or two allied subjects as minors. Usually no precise requirements are stated, but the minimum time in most institutions is three years of graduate work.

In order to elicit the information desired the editors of the GAZETTE selected seventeen institutions where they personally knew of the existence of well equipped laboratories and a vigorous head of the botanical department. To the head of the department was addressed a letter of inquiry, in which, to guard against misunderstanding, the following language was used:

> We wish to know what work in botany a student can obtain in your institution this year, who should come with three years of training in general botany and ask to enter for the doctor's degree. This information is intended not for the glorification of any university, but to give the actual status of the facilities for graduate work in American laboratories. It is not intended to give what the instructor might do had he more time, a better library, and more apparatus, but what he can do actually with his present limitations. This is making an unusual demand upon your time, but we are confident that you will aid us in making this statement as full and accurate as possible.
>
> In order that no essential point may be omitted we would suggest that not only the kind of work that is possible be described, but definite information given as to strength of library and collections, and also garden and greenhouse facilities. We shall take it for granted that the ordinary appliances are available.

Replies were received from all those addressed. Two of the seventeen replied that the institution did not offer the doctor's degree in botany at present. The reply from another stated no subjects in which research might be undertaken, so that it was not possible to include it in the summary given below. In addition to the information conveyed by letter we have used data derived from the handbook for graduate students, *Graduate Courses*, for 1896–7, and from the catalogues of the several institutions. All the data obtained have been arranged under the headings: staff; subjects offered; library; greenhouses and garden; collections; publication; remarks.

In giving the "staff" we have included all those concerned in instruction, so far as known to us, in order to indicate something of the strength of the department. For the same purpose we have also stated the number of volumes in the general library. While botanical works bear no necessary ratio to the whole, this furnishes a datum for estimate and for interpretation of the statements regarding the botanical library. In some cases the number of botanical works is stated, which is most direct and satisfactory.

It will be understood that under "subjects offered" are listed those divisions of botany within which the staff may be considered competent to suggest problems for research, and for which suitable facilities are now at hand. No account is taken here of any courses of instruction, whether offered to graduates or to undergraduates, though these may be an important factor in preparation for the examination.

Channels for publication are abundant; but certain institutions have journals or bulletins which are especially established to receive the results of research prosecuted at them. In such cases these have been indicated under the heading "publication."

In the following pages the institutions are arranged alphabetically. As far as possible the statements are given in the words of the writers.

UNIVERSITY OF CALIFORNIA.

Staff.—William A. Setchell, Ph.D., Professor; W. L. Jepson, Ph.B., Instructor; W. J. V. Osterhout, A.M., Instructor; J. Burtt Davy, Assistant in the Botanic Garden; C. P. Nott, Ph.B., Graduate Assistant.

Subjects offered.—CRYPTOGAMIC BOTANY. The cryptogams of California offer exceptional opportunities for research, and many simpler problems are presented for original investigation. This work will be confined, during the year 1896–7, almost exclusively to the algæ, in connection with the special work of the instructor.—Professor SETCHELL.

PHÆNOGAMIC BOTANY. Special problems requiring the original investigation of some particular order or smaller group of flowering plants. Work in the field as well as in the laboratory required.—Mr. JEPSON.

HISTOLOGY AND CYTOLOGY. Special problems in histology or cytology.—Mr. OSTERHOUT.

Library.—In the university library (65,000 volumes, 32,000 pamphlets) and that of the Academy of Sciences in San Francisco (nine miles away but readily accessible for a small fare) the important botanical works and periodicals are fairly well represented. For systematic work upon phænogams, and upon certain groups of cryptogams the literature is fairly complete. The works upon cytology are also well represented. There is some considerable representation of works upon vegetable histology and physiology.

Greenhouses and garden.—The new conservatory, recently completed, is a structure of iron and glass, and embodies the latest improvements; extreme length 170 feet, greatest width 60 feet, area about 7000 square feet; five subdivisions arranged for different temperatures. Especially for use of Agricultural Department.

The botanical garden occupies about seven acres of ground, of which about four have been laid out into garden plots. The remaining acres are in various degrees of preparation, but have already been planted with different shrubs and young trees. Altogether there are growing in the garden about 1500 species of plants, of which 1000 are perennial species and well established. About 1000 of these are Californian. Besides these there is a collection of seeds of about 2000 species, the greater part of them native. The plants of many different climates grow well out of doors. The collections of Australian, Chilian, Japanese, Chinese, African, and European species in common cultivation upon the university grounds and in the garden of useful plants of the Agricultural Department afford a rare opportunity for obtaining material.

Collections.—The herbarium of the university has been gathered by gifts and purchases around the nucleus of about a thousand species contributed by the State Geological Survey. The number of sheets now amounts to over 20,000 and there is sufficient unmounted material, which is being cared for as rapidly as the facilities will permit, to bring the number up to nearly 30,000. About two-thirds of these are given up to North American species. The remaining third is divided among the species of South America, Asia, Africa, Europe, and Oceanica.

The cryptogamic side of the herbarium has of late been especially developed, and already contains about 4000 specimens of ferns, mosses, hepatics, marine algæ, fungi, etc. The valuable collections of algæ, fungi, and lichens of Professor Setchell are deposited with the Botanical Department, and are accessible to advanced students.

Publication.—Short papers may be published in *Erythea*, a monthly journal edited by Mr. Jepson.

Longer papers and monographs requiring expensive plates may be published in the botanical volumes of *Proc. Cal. Acad. Sci.*, of which Professor Setchell is one of the editors.

THE UNIVERSITY OF CHICAGO.

Staff.—John M. Coulter, Ph.D., Head Professor; Edwin O. Jordan, Ph.D., Assistant Professor of Bacteriology; Bradley M. Davis, Ph.D., Instructor; Charles J. Chamberlain, A.M., Assistant; four Fellows who are members of the instruction force.

Subjects offered.—1. Special morphology of spermatophytes.—Professor COULTER.

2. Special morphology of algæ.—Dr. DAVIS.

3. Ecology, especially with reference to the problems of the dunes.—Professor COULTER.

4. Taxonomy of any group of spermatophytes.—Professor COULTER.

5. Bacteriology.—Dr. JORDAN.

Library.—General library 310,000 volumes, 180,000 pamphlets. The strictly botanical library contains about 3000 volumes, including complete sets of numerous periodicals, and several thousand pamphlets (not yet catalogued). The Newberry and Crerar libraries, both easily reached, add largely to the library facilities. A very complete list of current books and periodicals is received in exchange for the BOTANICAL GAZETTE.

Greenhouses and garden.—There are no greenhouses at present belonging to the university. The large houses in Washington Park, and the extensive planting both in Jackson and Washington parks (a few blocks east and west of the university respectively) supply almost unlimited material.

Collections.—The entire herbarium and library of Head Professor Coulter have been purchased by the university, containing a very full representation of the vascular plants of North America, and their literature. The collection is especially rich in types and standard sets.

Publication.—The BOTANICAL GAZETTE, published by the university, is the natural avenue for publication of papers from the department. Books may be issued by The University of Chicago Press.

Remarks.—A botanical club holds weekly meetings to discuss current research and publications.

The foregoing relates only to work offered this year. Enlarged space, facilities and staff, will be provided after the completion of the Hull Botanical Laboratory, now in course of construction.

COLUMBIA UNIVERSITY.

Staff.—Lucien M. Underwood, Ph.D., Professor; Carlton C. Curtis, Ph.D., Tutor; J. K. Small, Ph.D., curator of herbarium.

Subjects offered.—1. Anatomy and morphology both of spermatophytes and cryptogams. 2. Taxonomic work in nearly all groups. 3. Palæobotany, offered by the department of Geology.

Library.—General library, 225,000 volumes. The botanical portion contains about 4000 volumes and 5000 pamphlets shelved in herbarium room, besides general scientific series and serials containing botanical matter accessible in the general library.

The library of the New York Academy of Sciences, very rich in general scientific serials, is one floor above the herbarium.

The university collection contains almost complete files of nearly every serial ever published on botany, besides general works and special works. The cryptogamic portion is especially full on ferns, mosses, hepatics, lichens, and fungi.

Greenhouses and garden.—A greenhouse at Morningside, with some facilities for supplying living plants and space for simple physiological research. On future facilities, see below.

Collections.—(*a*) The herbarium contains about 600,000 specimens, being one of the largest in America; additions are at present made to it at the rate of about 20,000 specimens a year. It comprises: (1) The collections accumulated by Dr. Torrey, which came into the possession of the university at his death in 1873. (2) The collections of Professor C. F. Meisner, of Basle, Switzerland, presented to the university about the time of Dr. Torrey's death, by Mr. John J. Crooke. (3) The collections of Dr. A. W. Chapman, of Apalachicola, Florida, presented by Mr. Crooke at the same time, containing the types illustrating Dr. Chapman's "Flora of the Southern United States." (4) The mosses of the late C. F. Austin. (5) The mosses of the late Dr. J. G. Jaeger, recently acquired. (6) The fungi of J. B. Ellis, about 75,000 specimens, recently acquired for the New York Botanical Garden; in addition there are about 25,000 specimens of fungi in the general collections. (7) Miscellaneous accumulations since Dr. Torrey's death, now making up more than one-third of the whole collection. The herbarium is rich in types of species described by Dr. Torrey, Professor Meisner, Dr. Chapman, Dr. Asa Gray, Mr. Austin, Professor Britton, and Dr. Morong. The various collections are now all arranged in a single series, but each sheet is identified by a designative label or stamp. There are also extensive collections of fruits, seeds, woods, and material illustrating economic botany, placed in cases and drawers.

(*b*) The Jesup collection of woods in the American Museum of Natural History.

(*c*) Extensive economic collections and the Canby and Wood herbaria at the New York College of Pharmacy under the supervision of Professor Rusby.

(*d*) The Morong herbarium at Barnard College.

Publication.—The *Bulletin* and the *Memoirs* of the Torrey Botanical Club, and the *Transactions*, the *Annals*, and the *Memoirs* of the New York Academy of Sciences offer opportunities for papers; the University Press of Columbia University will issue books.

Remarks.—After the completion of the museum building of the New York Botanical Garden, the graduate research work will be conducted at that place where all the botanical facilities are to be centered.

CORNELL UNIVERSITY.

Staff.— George F. Atkinson, Ph.B., Professor; W. W. Rowlee, Sc.D., Assistant Professor; E. J. Durand, Sc.D., Instructor; K. M. Wiegand, B.S., Assistant; B. M. Duggar, A.M., Assistant.

Subjects offered.—1. Experimental morphology; with special reference to (1) sterilization of sporogenous tissue, (2) transformation of sporophylls, (3) homology of plant members, (4) teratological questions.

2. Experimental physiology, with special reference to the measurement of osmotic pressures.

3. Ecology, with special reference to relation and distribution of plants under peculiar conditions in central New York; distribution of fungi on hosts.

4. Comparative embryology; (1) embryology of sporophytic organs; (2) embryology of gametophytic organs; (3) accompanying cytological problems.

5. Morphology of fungi; monographic studies of certain genera.

6. Development of fungi; special and comparative studies of genera.

7. Structure and development of algæ; special facilities for the study of cystocarpic development in Florideæ.

8. Cytology in the broad sense.

9. Comparative histology; with special reference to development of vascular tissue, and secondary thickening of the cambium; tissues of seedlings; relation of histology to taxonomy.

10. Special morphology of higher plants, with reference to special forms assumed by different members.

Library.—General library contains 190,000 volumes and 50,000 pamphlets. A large number of current journals are received. Botany has a good showing in the library, but it would be impossible to give an accurate or even approximate statement since so many of the important articles are found in transactions and proceedings of societies.

Greenhouses and garden.—Five different houses of different temperatures, with a variety of exotic plants, some native plants, space for growing plants in physiological experiments, and material for illustration and use in the laboratories.

A garden for illustrations and for growing plants, to supply certain of the wants in the laboratory, as well as for experimental purposes.

Collections.—A small but growing herbarium of about 15,000 species.

HARVARD UNIVERSITY.

Staff.—George L. Goodale, M.D., LL.D., Professor Nat. Hist. and Director of Botanic Garden; Wm. G. Farlow, M.D., LL.D., Prof. Crypt. Bot.; Roland Thaxter, Ph.D., Asst. Prof. Crypt. Bot.; H. L. Jones, A.M., Instructor; Arthur B. Seymour, M.S., Asst. in Crypt. Herb.; Albert R. Sweetser, A.M., Asst.; Frederick O. Grover, A.B., Asst.; Jos. W. Blankinship, Asst.

Subjects offered.—1. Structure and development of phanerogams. 2. Physiology. 3. Taxonomy of pteridophytes and phanerogams. 4. Economic and medical botany.—Professor GOODALE.

5. Structure and development of cryptogams.—Professors FARLOW and THAXTER.

In the case of candidates for degrees, who are generally young men just beginning their botanical career, it has been the practice in the cryptogamic laboratories to set them to work on some histological or developmental subject rather than upon descriptive systematic work; it being the opinion that, while a beginner may be able to accomplish something valuable in the first-named field, purely systematic work worthy of publication cannot be expected except after a number of years have given a broad, practical knowledge and matured the judgment. In the case of candidates for a degree, students are allowed to select subjects in accordance with their individual tastes, provided such subjects can be properly worked up in the two or three years of candidacy.

Besides candidates for the doctor's degree, the university offers the means for research to persons specially qualified who reside at the university, for the purpose of pursuing some special piece of work. These are in general visiting botanists and specialists who remain for periods varying from a few days to a few months, and they are often occupied with systematic work; to such persons the libraries are freely accessible, and they are allowed to consult the herbaria under the charge of the curators.

Library.—The general library of the university contains 468,000 volumes and 450,000 pamphlets. Students have free access to the large special botanical libraries in Cambridge and Boston and the private libraries of the instructors. The former furnish valuable series of journals and proceedings and the latter special papers and monographs. The special library at the Gray Herbarium contains 9000 volumes and pamphlets.

Greenhouses and garden.—The greenhouses are located at the Botanic Garden, half a mile from the general laboratories. Special laboratories are available at the garden, when desired. The plant houses are arranged for various temperatures and conditions.

The garden embraces seven acres fully planted, and contains over 5000 species.

Collections.—If the material to be studied is histological, the student is provided with alcoholic, or dried material, of which a considerable amount is kept on hand to illustrate certain points which sooner or later should be investigated. If the subject requires living material, the country near Cambridge and the seashore furnish abundant material.

The herbaria at the museum are rich in fungi, algæ and lichens, and at the Gray Herbarium are valuable collections of higher cryptogams and mosses. The lichens include the Tuckerman collection together with a number of other native and exotic collections; the fungi include the Curtis collection and a large series of published exsiccati; and the algæ are represented by several valuable foreign collections and exsiccati, besides the large collection of American algæ.

There are extensive collections of economic products in the museum.

The Gray Herbarium of over 200,000 sheets, and rich in types, affords extraordinary opportunity for research in phanerogamic taxonomy. It also contains several important collections of mosses.

Remarks.—A botanical club holds fortnightly meetings.

The staff of the Gray Herbarium is not included above, as its duties are not primarily instructional.

UNIVERSITY OF ILLINOIS.

Staff.—T. J. Burrill, Ph.D., LL.D., Professor; G. P. Clinton, M.S., Instructor; C. F. Hottes, M.S., Assistant.

Subjects offered.—1. Taxonomy of fungi and fresh water algæ. 2. Bacteriology. 3. Histology. 4. Physiology.

Library.—General library of 28,200 volumes and 6200 pamphlets contains about 2000 volumes strictly botanical. Includes complete sets of all the prominent European and American periodicals (save the English illustrated and expensive publications), and most of the standard works on physiological, pathological and economic subjects. The fungi are especially well represented.

Greenhouses and garden.—There is no garden. Greenhouses on the university grounds contain plants of many kinds, not collected for any particular line of study. The facilities of the houses for propagation, growth in pots, etc., are available. Attached to the laboratory for vegetable physiology is a small conservatory 14 × 19 ft., two stories high, with aquarium tank 6 × 14 ft. in lower room.

Collections.—The herbarium is small (about 25,000 species, mounted) but is rich in parasitic fungi. There is a very nearly complete set of Illinois flowering plants and ferns. The grasses are well represented.

Remarks.—A biological station established at Havana, Ill., on the Illinois river, contributes special facilities for investigations upon aquatics.

JOHNS HOPKINS UNIVERSITY.

Staff.—J. E. Humphrey, S.D., Lecturer.

Subjects offered.—Morphology.

Library.—The library of Capt. John Donnell Smith (which has been offered to the university) is near by and is accessible to properly prepared students. It is rich in the literature of the taxonomy of spermatophytes, and in serials.

Besides this library, those of the neighboring Peabody Institute, of the university (76,000 volumes and 55,000 pamphlets), and of the instructor, contain much important botanical literature. Altogether, the most important books, full sets of nearly all the journals, and of the proceedings of the chief learned societies are readily accessible.

Greenhouses and garden.—None.

Collections.—The collections in the care of the university are small, comprising the Schimper herbarium of European and African phanerogams, the local collections of the Naturalists' Field Club, the Fitzgerald collection of mosses, and the private herbarium of the instructor, chiefly of thallophytes. The herbarium of Capt. Smith is also accessible to students.

Remarks.—Graduate work in botany is a matter of recent development at the Johns Hopkins University, and the number of students who can be accommodated is limited.

LELAND STANFORD JUNIOR UNIVERSITY.

Staff.—Douglas H. Campbell, Ph.D., Professor; Wm. R. Dudley, M.S., Professor; Walter R. Shaw, A.M., Instructor.

Subjects offered.—Life-history of one of the lower monocotyledons, hepatics, or pteridophytes; comparative organogeny; special problems in cytology; systematic study of special groups of native plants.

Library.—The university library consists of 30,000 volumes, and 10,000 pamphlets. In botany it contains standard works of general character up to date, and complete sets of several of the more important journals. It is supplemented by private libraries of professors, especially rich in separates pertaining to special subjects.

Greenhouses and garden.—There are two greenhouses on the grounds, but not conveniently situated, so that they are little used. Material is chiefly derived from the wealth of vegetation growing out of doors, both wild and cultivated. The university tract of 8000 acres embraces a great variety of surface, and furnishes an abundance of materials of all sorts. Extensive plantations of exotic and native plants, including a great variety of trees and shrubs, offer unusual opportunities. Moreover, the mountains and seashore are both readily accessible.

Collections.—The herbarium now contains about 25,000 species. The collections and library of the California Academy of Sciences at San Francisco (33 miles away) are also available.

Remarks.—The Hopkins seaside laboratory at Pacific Grove, an adjunct of the biological department of the university, offers especially good facilities for the study of the rich marine flora.

UNIVERSITY OF MICHIGAN.

Staff.—Volney M. Spalding, Ph.D., Professor; F. C. Newcombe, Ph.D., Assistant Professor; J. O. Schlotterbeck, Ph.D., Assistant Professor; Jas. B. Pollock, M.S., Assistant; Fannie E Langdon, B.S., Assistant.

Subjects offered.— Morphology. Physiology.

Library.— General library contains 100,000 volumes, 18,000 pamphlets. The special botanical books are shelved in the laboratory. They comprise sets of journals and other periodical literature and monographs.

Greenhouses and garden.— Space is provided in a neighboring conservatory and garden where plants under investigation are cared for by an attendant.

Collections.— The laboratory contains a large collection of alcoholic material and an herbarium of about 100,000 sheets representing about 14,000 species. The collection of fungi includes Ellis and Everhart, Briosi and Cavara and other valuable sets, and a large representation of species occurring in Michigan. Arrangements are also made by which abundant marine and tropical material is provided when needed.

Remarks.— The income of the laboratory makes it possible to promise an investigator anything that he really needs in the way of material and apparatus.

A journal club of a dozen or fifteen instructors, investigators, and advanced students meets weekly for reports on current literature.

UNIVERSITY OF MINNESOTA.

Staff.— Conway MacMillan, A.M., Professor; D. T. MacDougal, A.M., M.S., Assistant Professor; F. Ramaley, M.S., Instructor; A. A. Heller, Instructor; Josephine E. Tilden, B.S., Instructor.

Subjects offered.— Comparative morphology, anatomy and embryology; ecology; cytology; algology and mycology; ecologic distribution.

Taxonomy of Spermatophyta and Pteridophyta.

Physiology, with special reference to irritability, the directive and formative influence of environmental factors.

Special research. Students with expert knowledge are encouraged to select special problems and carry them along to some useful and adequate solution. For such investigations it is the policy of the institution to provide any reasonable facility in the way of special apparatus, material and literature. The university does not hesitate at expense if there be the opportunity of developing some important research under its supervision.

Library.— The general botanical library contains about 2200 bound volumes and 3800 separates. Especial care has been exercised to procure complete sets of periodicals, and practically all the important botanical journals, with the exception of *Curtis' Magazine*, *Oesterreichische Botanisches Zeitschrift* and *Nuovo Giornale Botanico Italiano*, have been purchased entire or are easily available. Certain special fields are well represented in the collection, but it is the plan of the department to furnish exhaustive series of literature only when a definite problem is to be settled. Of course all the botanical bibliographies are at hand, and there is absolutely no reason in any given case why everything that has been done upon any given topic should not be brought to light.

The physiological section includes about 200 volumes and 1000 separates shelved in the laboratory. Literature not purchasable may be obtained by loan from a German institute by a personal arrangement of the instructor.

The mycological and algological collections are likewise shelved in the respective laboratories, and a large section of the taxonomic library is shelved in the herbarium.

Collections.— Besides several hundred specimens of wood from different parts of the world and as many jars of alcoholic and formalose material, the herbarium with its 200,000 specimens (in round numbers) is an important part of the equipment. It is being developed upon the broadest basis. Plants of all orders and from every part of the world are either already included in its cases or are among its desiderata. It now serves as a very adequate reference collection for North American taxonomy and is rich also in Mexican, European, African, and Asiatic material.

It continues to increase rapidly in size and value and, as in the library, efforts will be made to supply as full an illustrative series of plants as possible, for whatever special research may be taken up.

Greenhouses and garden.—The plant house (20 × 40 feet) is inadequate at present but suffices for the maintenance of some 300 species of plants that are used in morphological work. Besides its further function as an adjunct to the laboratory of plant physiology, its principal use is as a depot for native plants freshly taken from their stations. There is no garden.

Publication.—*Minnesota Botanical Studies*, a quarterly or occasional series of papers, offers a medium of publication for the researches of the department. Plates are provided as needed and separates are struck off when requested.

Remarks.—In morphology and ecology the university offers to a limited number of graduate students every facility desired in the way of instruments, reagents, literature and material. There are accommodations at present for twenty. Problems in cytology, in embryology, and in anatomy are particularly kept in mind by the instructor. Special laboratories, three in number, are at the disposal of graduates in these lines. Collecting trips to different parts of the state can be arranged; cameras are provided for ecologic work, and camping outfits are furnished those who desire to spend some time in the field.

The department is prepared to assist in the taxonomic revision of any North American genus or family, and either has or will procure a full set of material for study. An exchange bureau is maintained in connection with the herbarium, through the correspondence of which a large number of American collectors can be reached.

The accommodations in physiology are sufficient for six students. The instructor has in hand notes and material upon which a student may profitably engage in the investigation of certain problems in the formative and directive influence of external factors, irritability to contact and impact, transmission of impulses, curvatures, growth correlations, and the physiology of storage tissues and color layers. Beside the usual physiological apparatus, a number of pieces of more or less complex apparatus of special design, which were constructed for the solution of problems under investigation, have been accumulated. Such appliances are often found to be of very great value in other work. New and necessary apparatus may be purchased, and that designed by the investigator can be made very promptly by the instrument makers to the electrical and physical departments.

THE UNIVERSITY OF NEBRASKA.

Staff.—Charles E. Bessey, Ph.D., Professor; Frederic E. Clements, B.S., First Assistant; Cornelius L. Shear, Second Assistant; Edna L. Hyatt, Botanical Artist.

Subjects offered.—1. Plant morphology. Work in several lines of morphology has been given successfully for several years.

2. Systematic botany *A*, being the study of a selected group of plants. Here the student will find ample material for the study of all the important groups (classes, most orders, and many families). The herbarium has been built up in such manner as to represent as fully as possible all the important groups.

3. Systematic botany *B*, being the study of a local flora, and the preparation of a catalogue. The plains, and the mountains to the west, afford ample facilities for this work, supplemented by the quite full herbarium of the Botanical Survey of the state.

4. Phytogeography. The collections made by the Botanical Seminar afford ampie material for profitable study.

Library.—The university library contains 34,000 volumes, and the botanical library about 2000. In the university library 467 periodicals are received, in the botanical library 43. Of many of these it has complete sets; of others its files run back ten or twelve years; while of still others the files are but a few years old.

Greenhouses and garden.—There is a steam-heated greenhouse of 4200 sq. ft. of glass, with tank for aquatics; no garden.

Collections.—The herbarium contains from 70,000 to 80,000 specimens, and includes exsiccatæ by Wittrock and Nordstedt, Rabenhorst, Le Jolis, Ellis and Everhart, Thueman, M. A. Curtis, Romell, Linhart, Sydow, Shear, Seymour, Tuckerman, Stenhamer and Fries, Massalongo, Seymour and Cummings, Gottsche and Rabenhorst, Austin, Underwood and Cook, Heller, A. H. Curtiss, Harvey, Rydberg, etc. The quite complete herbarium of the Botanical Survey of Nebraska, by the Botanical Seminar, is also available for study.

Publication.—Ample opportunity for publication is afforded by "Contributions from the Botanical Department of the University of Nebraska," "Bulletin of the University Experiment Station," "University Studies," "Reports of the Botanical Survey," and "Flora of Nebraska." The two last are published by the Botanical Seminar.

Remarks.—A shop for the construction of apparatus is equipped with tools, lathe, anvils, etc.

The Botanical Seminar is a very active organization, largely interested in the study of the state flora. At its bimonthly meetings botanical papers are read and critically discussed. Admission to membership is attained upon passing an examination in the anatomy and morphology of the spermatophytes, morphology and development of the lower plants, embryology of spermatophytes, taxonomy, bibliography, etc.

PURDUE UNIVERSITY.

Staff.—Stanley Coulter, Ph.D., Professor of Biology; J. C. Arthur, Sc.D., Professor of Physiological and Pathological Botany; Katherine E. Golden, M.S., Instructor in Biology; Severance Burrage, B.S., Instructor in Bacteriology; William Stuart, B.S., Assistant.

Subjects offered.—Histology; taxonomy of spermatophytes.—Professor COULTER. Physiology; ecology; pathology.—Professor ARTHUR. Bacteriology.—Mr. BURRIDGE.

Graduate work in these subjects is carried on with accommodations provided jointly by the university and the Agricultural Experiment Station.

Library.—The botanical resources of the university library (8000 volumes) are only moderate. The private library of the professor of physiological botany, kept at his residence, contains about 800 bound volumes and 2000 pamphlets, and is especially rich in works on physiology, pathology and fungi. The works have been purchased as need for them arose, and additions are being constantly made. It is open freely to the use of students.

The botanical part of the library of the station is also available, and consists of about 200 volumes, of which about one-half is embraced in nearly or wholly complete sets of *Berichte der deutschen botanischen Gesellschaft*, *Botanisches Centralblatt*, *Centralblatt für Bakteriologie und Parasitenkunde*, and Just's *Botanischer Jahresbericht.*

Greenhouses and garden.— From the general laboratory a door opens directly into the greenhouse, which may be considered as a glass covered portion of the laboratory, being on the same level, with tight floor and table topped benches. The greenhouse is small, but is entirely devoted to research work, the usual collection of conservatory plants being almost wholly excluded. It is in two independent parts, permitting different degrees of temperature to be maintained. The university conservatories, not far away, contain a good general assortment of plants, which may be drawn upon if required.

The garden has but a temporary value, and consists of a plot of ground a few steps from the laboratory, having a few shrubs and perennials, but available for the accumulation or cultivation of plants required for an investigation. The glass covered vegetation house is 20 × 50 feet, but is serviceable chiefly for summer work.

Collections.—The herbarium of the biological department contains about 6500 mounted sheets of phanerogams, and is especially rich in the plants of Indiana. The herbarium of the professor of physiology, including probably six thousand species, is only in small part readily accessible, being unmounted. The mounted part consists of about 1300 sheets of phanerogams and 1600 sheets of fungi, nearly three-fourths of the latter being Uredineæ.

Publication.—The *Bulletin* of the Agricultural Experiment Station has provided for the publication of research work.

Remarks.—A machine room, provided with a lathe and assortment of iron and woodworking tools, and a skilled mechanic when required for making needed apparatus, is maintained.

Smith College.

Staff.—William F. Ganong, Ph.D., Professor; Grace D. Chester, B.S., Instructor in Cryptogamic Botany.

Subjects offered.—Morphology; ecology.

Library.—Contains all ordinary reference works; is being strengthened rapidly, particularly in morphology and ecological phases of physiology. The Forbes Library, richly endowed, practically on the college grounds, buys the more expensive works if not too technical. Amherst Agricultural College library (seven miles away with railroad between) is rich in complete sets of botanical and agricultural journals and proceedings, and is accessible freely to all students.

Greenhouses and garden.—The college possesses a garden, with systematic and ecological sections being rapidly developed. Some 800 species are in cultivation out of doors. There is a nursery available for experiment. The range of greenhouses is in every respect thoroughly efficient, and fairly stocked, particularly with plants selected to illustrate morphological and ecological principles. Includes (*a*) experiment house 20 × 30 ft. with special stages directly on brick piers; attached to it is a small laboratory 20 × 15 ft.; (*b*) cool temperate house 20 × 30 ft.; (*c*) acacia and succulent house, 20 × 17 ft.; (*d*) palm house 56 × 35 × 25 ft. high; (*e*) tropical house 32 × 20 ft.; (*f*) warm temperate and aquatic house 45 × 20 ft., propagating house 5 × 60 ft., working house, etc. The entire range is exclusively for botanical purposes, and any part of it and its stock is available for investigation, and materials therefore can be grown in any quantity and with all proper conditions.

Collections.—The herbaria are small; the phanerogams just under 4000 sheets; the cryptogams 2500; both general.

Remarks.—Smith College does not especially encourage graduate work at present, as it is devoting its main resources to strengthening its undergraduate course in all directions. Nevertheless it does not decline to receive graduate students and it confers the Ph.D. degree upon the conditions usual in institutions of the first rank.

UNIVERSITY OF WISCONSIN.

Staff.—Charles R. Barnes, Ph.D., Professor of Botany; H. L. Russell, Ph.D., Professor of Bacteriology; L. S. Cheney, M.S., Assistant Professor of Pharmaceutical Botany; W. S. Marshall, Ph.D., Assistant Professor of Biology; W. D. Frost, Assistant in Bacteriology.

Subjects offered.—1. Physiology, especially nutrition; Bryology.—Professor BARNES.

2. Agricultural and Dairy Bacteriology.—Professor RUSSELL.

3. Histology, especially of medicinal plants.—Professor CHENEY.

Library.—The university library is deficient in many respects. It contains about 45,000 volumes and 10,500 pamphlets, of which about 1000 and 200 respectively are especially botanical, including full sets of many important periodicals. Such as are most used are shelved at laboratories. It is quite complete in the taxonomy of bryophytes. It is supplemented by the libraries of the State Historical Society and the Academy of Sciences, Arts, and Letters (about 200,000 volumes and pamphlets), which contain many sets of transactions, etc., and some of the expensive general works; and by the private libraries of the professors, containing many separates.

Greenhouses and garden.—The physiological laboratory opens into a small conservatory 9 × 18 ft. for experimental work only. Large greenhouses belonging to the Agricultural Department supply growing material at all seasons, but are too far away (half a mile) for direct use. There is no garden. About four acres of campus, a hundred yards from laboratory, are kept in original wild state with native trees and undergrowth and supply material during the growing season. Adequate supplies of alcoholic and formalin specimens are kept for research in histology and morphology.

Collections.—The general herbarium contains about 10,000 species. Special attention is given only to building up the herbarium of Wisconsin plants and of North American mosses. The latter is almost complete and has many sets of exsiccati.

Publication.—The *Bulletin* of the university of Wisconsin, Science Series, and the *Bulletin* of the Agricultural Experiment Station afford special facilities for publication.

Remarks.—The university creamery furnishes unusual opportunities for research in dairy bacteriology upon a commercial scale. A journal club holds weekly meetings.

SOME NEW SPECIES OF MINNESOTA ALGÆ WHICH LIVE IN A CALCAREOUS OR SILICEOUS MATRIX.

JOSEPHINE E. TILDEN.

(WITH PLATES VII–IX)

DURING the past three seasons there have been observed near Minneapolis several species of algæ which deserve attention from their peculiar manner of life, since they occupy not the surface but the interior of rock formations. They exist, therefore, under conditions of low illumination.

In the summer of 1894 a curious incrustation was noticed lining the sides of an old sunken tank which had formerly been used in connection with a rendering factory. The tank is situated on the eastern bank of the Mississippi river, two miles below this city. It is nearly forty feet square and six to nine feet deep, having a muddy bottom. The walls are of boards standing upright side by side and driven in like piles. The incrustation extends from the surface of the water downwards to a distance of perhaps three feet, where, becoming thin and scaly, it gradually disappears. Its thickness in 1894 was in the neighborhood of 2^{mm}. By the following year there was an increase to 6^{mm}, and in the present season it has attained an average thickness of 10^{mm}.

The crust covering the southwest side of the tank varies in color. Dull and bright æruginous, steel and brownish tints predominate, the two latter corresponding most nearly to the shades *cæsius* and *isabellinus* as given in Saccardo's *Chromotaxia*. A close view of the surface shows it to be indented by very minute pores or depressions, which may be compared roughly to the markings on some of the corals and other lime secreting sea animals (*pl. VII*).

Subjected to chemical tests the incrustation is found to be made up almost wholly of calcium carbonate in the amorphous form, and organic material. It is exceedingly porous, absorbing water readily when dry, and is also very friable.

A microscopical investigation shows the presence throughout the stratum of species of algæ belonging to the Cyanophyceæ. Three species are found to be constant, a Dichothrix and two species of Lyngbya. Numerous diatoms and scattered cells of Glœocapsa are also present. The difference in color of the surface of the stratum is found to be due to the position of the above three species. When the Dichothrix appears on the surface a shade of light brown with a tinge of pink is given, or at times a bright cæsius blue. The Lyngbyas occasion the æruginous tints.

The calcareous matrix contains constantly an organism evidently fungal in character and corresponding in all respects to the chlamydospore-bearing filaments of *Pseudohelotium granulosellum* as figured by Brefeld.[1] The extraordinary occurrence of this fungus I am quite unable to explain, and its origin and development in the matrix must receive further study before anything of importance can be said about it.

In general the relative positions of the three algal species are as follows: the Dichothrix possesses the widest range and is the most abundant of the three. It occurs farthest from the light in the older portions of the lime stratum, as well as at the surface. Its arrangement is for the most part zonal. The filaments are parallel and stand perpendicular to the plane of the stratum. The large Lyngbya does not extend downward so far as the Dichothrix. It prefers, evidently, the area just beneath the surface of the crust, but at times it reaches the extreme surface. Its filaments form a tangled network. As a rule the small Lyngbya is found at the top of the matrix and immediately below the surface. The lower filaments consist of empty sheaths.

The growth on the remaining three sides of the tank shows a somewhat different structure (*pl. VIII*). The incrustation just described now appears as the substratum, its surface being covered by the thalli of *Chætophora calcarea*, which was distributed as no. 11 in *American Algæ, Century 1.*

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[1] Untersuchungen, Heft 10, *pl. 12, fig. 26.*

The thalli project from the substratum. They form somewhat globose mounds, or later these are confluent into sharp ridges or shelves parallel to the surface of the water. These shelves may be compared in shape to a Polyporus and are peculiar in construction. The upper portion consists of the Chætophora thalli proper, being in color a chlorophyll green; the substructure is made up of the blue-green species, notably the larger Lyngbya, which causes the bright purplish-blue color. Evidently, in the beginning, the Chætophora thallus is solitary, has a globose form, and stands out at right angles to the substratum, thus presenting one side to the direct light of the sun, while the opposite side is in the shade. The Lyngbya seizing the opportunity offered for additional room and indirect light soon forms a growth upon the under side of the Chætophora thallus. This in turn takes advantage of the support given by the Lyngbya, which it uses as a substratum, and takes an upright position to receive on all sides alike the direct sunlight. Thus the two plants develop, keeping pace with and aiding each other, until eventually the above mentioned structure is formed. It may be said that the Lyngbya forms a shelf upon which the Chætophora thallus may rest, or that the Chætophora makes of itself a screen for the protection of the Lyngbya. This is a distinct and somewhat peculiar form of symbiosis.

For a time it remained a problem why the Chætophora should be confined to the three sides of the tank, while the blue-green plants occupied also the fourth side. With some difficulty the position of the inlet of the tank was located. It was found that the water enters in the corner facing the south, that it flows out again at the west corner in a stream a foot in width, almost immediately disappearing in the ground. From this it appears that there is a current along the southwest side of the tank. Elsewhere the water, while not stagnant, is not subject to so much movement that it might be called running water. This then is the probable reason for the arrangement of the plants. The preference of Chætophora for quiet, pure water is known, while Lyngbya and Dichothrix flourish in waters either with or without a current.

The Chætophora thalli are strongly impregnated with lime and are hard, making decalcification necessary before examination under the microscope. The nature of the calcium carbonate in these thalli differs from that in the substratum. Here it appears in the form of crystal plates which, under the high power of the microscope, have a striated appearance. This results from the fact that they have running through them perforations or tubes corresponding in size and form to the Chætophora filaments. Branches of the Chætophora may be observed indeed entering these tubes and emerging at the opposite side of the crystal plate (*pl. IX, fig. 6*). If a longitudinal section be cut from a thallus and placed under the lens, the crystal plates being left intact, it will be seen that these pipes or tubes radiate from the center, following exactly the trend of the branches and for the most part containing the branches, though it is somewhat difficult to focus closely enough to observe the latter point with the thick crystals under the coverglass (*pl. IX, fig. 7*).

The Chætophora, as well as a thin growth of the blue-green plants, occurs on dead limbs which have fallen into the water from the trees on the banks. A few of the twigs taken out of the tank late in the autumn displayed after drying a violet tint on their under surface. This was caused by the presence of a small Chantransia, which, like the other algæ, was incrusted with lime. Its color when growing was probably green, since otherwise it would have been noticed before it was dry. It was accompanied by both the Lyngbyas, similar in all respects to those found in the stratum on the sides of the tank, with the exception that their cell contents had now assumed a bright violet color. In rare cases filaments were still found with the former æruginous tint, and some belonging to the larger species had a brown color. The change in color from æruginous to violet may have some connection with the approach of cold weather. It was also noticed that the sheath of the larger Lyngbya had become corrugated or roughened and somewhat wider.

It is thought that these five algæ, which have just been described, are capable, either alone or in combination, of causing the precipitation of calcium carbonate. If the deposit is not formed in this way, it must be because the water contains a large quantity of calcium carbonate which is laid down as the result of evaporation. In this case these algæ have become adapted to a life within a calcareous envelope. As a matter of fact the water is not rich in carbonates. An analysis kindly made for me by Professor G. B. Frankforter shows the following results:

Total solids, - - - -	36 grains per gallon.
Calcium carbonate, - - -	18 " " "
Calcium sulphate, - - -	17.5 " " "
Sodium chloride, - - - -	trace.
Magnesium sulphate, - -	trace.

Another fact in favor of the supposition that the plants act as agents in the deposition is that the precipitation of calcium carbonate takes place only where the plants occur, and not indiscriminately upon every object exposed to the action of the water. A dead branch of a tree, after being in the water a year, was taken out to be preserved. The top and sides, as it lay in the water, were covered with a luxuriant growth of the several blue-green algæ and the Chætophora. On its under shaded surface the algæ would not live, nor was there a trace of lime to be found there. Again, the water has formed a ditch around the outside of the tank, deep and narrow, and therefore dark. For the latter reason no algæ grow on the back of the boards, and no deposit is formed there, though they are washed by the same water that circulates through the interior of the tank.

In certain waters at Mammoth Hot Springs, Yellowstone Park, where tourists suspend articles to be incrusted, the deposit coats the entire surface of the object. In this case the lime is deposited through exposure to the air of water containing a great abundance of calcium carbonate, and not through the agency of algæ.

It has not been proved that any one of the blue-green species or the Chantransia is able by itself to produce a separation of the carbonate, but two facts show the Chætophora to be independent of the others in its secretion of lime; first, its thalli are not engulfed in the substratum, and, second, the calcium carbonate is deposited in crystal plates instead of amorphous particles.

Until recently the only additional inhabitants of the tank have been a species of moss, a Fontinalis, which formed a rich growth all over the bottom of the tank, and the little fresh-water shrimp, *Gammarus pulex*, which is present in exceedingly great numbers. During the latter part of the recent summer, however, the water has appeared less pure, and a heavy growth of Spirogyra spread over the surface. The blue-green algæ remain unchanged, but the Chætophora has not thrived so well. It must be noted that not all the plants growing in the tank possess the ability to cause the precipitation of lime. Neither the moss nor the Spirogyra show a tendency to do so.

In preparing a slide of the above material it is a good plan first to soak a piece thoroughly in water, then cutting off a thin section with a scalpel place in a dish of diluted hydrochloric acid and warm gently. When the bubbles of CO_2 cease forming, it can be mounted in water or glycerine. Before putting the cover glass in place, it is well to tease apart the filaments with needles, for the section is likely to be too thick for perfect transparency.

Dichothrix calcarea Tilden, Am. Alg. Cent. II. no. 165. 1896. (*pl. IX., figs. 1–3*)—In extended strata either on surface of calcareous matrix, giving it then a brownish or sometimes a light æruginous tinge, or in layers throughout the matrix. Filaments 9–12.5µ in diameter, erect, not rigid; pseudobranches appressed; sheath rather thin, hyaline; trichomes brown, sometimes æruginous, up to 10µ in diameter, for the most part moniliform in lower portions, tapering to a point; articulations in lower portion of filament equal in length to diameter, shorter in upper portions; heterocyst basal, globose or depressed globose, diameter equal to or a little smaller than that of filament.

This plant does not seem to be very near any of the species of Dichothrix as described by Bornet and Flahault. The filaments are strongly agglutinated, and this with the moniliform character of the trichomes make it peculiar.

LYNGBYA MARTENSIANA **calcarea** Tilden, Am. Alg. Cent. II. no. 178. 1896. (*pl. IX., fig. 4*)—In extended strata throughout upper portions of calcareous deposit. Filaments elongate, straight, flexible, somewhat unequal in size, average 6.5-7.5μ in diameter; sheath very distinct, hyaline, smooth or rough; trichomes dull æruginous, violet, or rarely brown, frequently interrupted, not constricted at joints, not or very rarely attenuate at apex, 5-6.5μ in diameter; articulations 2-3 times shorter than diameter, average 2.5μ long; dissepiments often inconspicuous or marked with granules; apical cell rotund; calyptra none.

L. martensiana has been found only in thermal waters. The temperature of the water in the tank is 12 C. during the summer. The filaments of the species are somewhat larger and the articulations shorter than those of the variety, but otherwise the points agree very well.

Lyngbya nana Tilden, Am. Alg. Cent. II. no. 179. 1896. (*pl. IX., fig. 5*)—In extended strata on or near surface of deposit. Filaments 1.9μ in diameter, straight; sheath delicate, hyaline, smooth; trichomes very pale steel color becoming violet later in the season, not constricted at the joints; articulations 1.6μ in diameter, quadrate or 1.5 times the diameter in length; apical cell rotund.

In Gomont's monograph there are but four species of Lyngbya described whose size will permit of comparison with *L. nana*. Of these *L. Lagerheimii* is easily distinguished from it by the spiral filaments; *L. rivulariarum* by the constriction at the dissepiments, length of the articulations and habit of growth; *L. ochracea* differs in the peculiar character of its stratum; *L. purpurea* agrees more nearly than the others. The measurements are alike, the joints show no constriction. The violet color, however, which in the last species appears to be constant, is peculiar to a certain stage only of *L. nana*. The habit and habitat, likewise, distinctly separate the two.

Chætophora calcarea Tilden, Am. Alg. Cent. I. no. 11. 1894 (*pl. VIII.* and *pl. IX., figs. 6–7*)—Thalli globose, subglobose, or confluent into ridges, encrusted with lime. Lower cells 9μ in diameter, 3–5 times as long; upper cells 8–12.5μ in diameter, two times as long; articulations distinctly contracted at joints; terminal cells usually rather blunt, sometimes ending in very long articulated setæ.

The presence of lime in the thallus has been employed as a varietal character in the genus Chætophora in two instances, viz.: *Chætophora cornu-damæ* (Roth) Ag. var. *crystallophora* Kg. and var. *incrustans* Rabenh. An examination of herbarium material comprised under eight species indicates the presence of lime in quantity in twenty-seven out of forty-five cases. Eighteen specimens show no trace of the substance. Out of twenty specimens of *C. cornu-damæ*, ten showed strong indications of lime, four of these being of the var. *crystallophora*, and two being of the var. *clavata*. Eight out of the nine specimens of *C. tuberculosa* were encrusted with lime.

Kjellman's specimen from the polar sea, *C. pellicula*, said to form a crust 200–300μ in thickness, is in all probability a lime secreting plant.

C. calcarea and a plant nearly related to this genus, *Stigeoclonium flagelliferum* Kg. (*Pilinia diluta* Wood), both studied in this laboratory, possess the capacity of secreting lime to a remarkable degree. In both the calcium carbonate is deposited in the form of crystal plates, which are penetrated by the filaments and branches of the plant.

Taking these facts into account, it would seem that the presence or absence of lime in Chætophora thalli should be regarded as a factor in the determination of the species.

CHANTRANSIA PYGMÆA (Kg.) Sirodot, Les Batrachospermes 244, 245. 1884. Am. Alg. Cent. II. no. 112. 1896 (*pl. IX., fig. 8*)—Stratum very thin, when dry forming a violet-colored calcareous crust on lower shaded surface of dead twigs. Filaments straight; branches erect, sometimes appressed to stem, apices somewhat attenuate; articulations 11–12μ in diameter, in general 2–3 times the diameter in length; branches bearing sporules short, situated in upper portion of the plant; sporules in general 2–3 upon a branch.

The description of the asexual form of *Batrachospermum crouanianum*, as given by Sirodot, seems to cover fairly well the characters of the above plant. But, so far as is known, the capacity for secreting lime has not hitherto been noted in connection with this species.

A still more curious alga is one which inhabits the white sandstone cliffs at a point where Minnehaha creek flows into the Mississippi river. The rock presents no trace of plant life on its outer face, which has the usual appearance and light gray color of weathered white sandstone. But small pieces broken off and held up to the light show fine colorless threads hanging from the inner side of the fragments. These are filaments of a Schizothrix. The plant is found at least one-half inch from the outer surface. The amount of light received by it is necessarily extremely small, for the reflecting surfaces offered by the crystals are very numerous in such a thickness of stratum.

There is some difficulty in extracting the algal threads from the sand grains. The only satisfactory method is to moisten a bit of the material and place it under the low power of the microscope. The grains can then be removed with a needle, allowing the filaments to remain. It is necessary to use a $\frac{1}{16}$ oil immersion lens in order to observe the dissepiments.

Schizothrix rupicola Tilden, Am. Alg. Cent. II. no. 175. 1896 (*pl. IX., fig. 9*)—No definite stratum. Filaments 9.6–16μ in diameter; sheath cylindrical, rough, for the most part hyaline, sometimes brownish and much lamellated; trichomes pale æruginous, one to many in a sheath, not constricted at joints, 3.5–4.8μ in diameter; articulations 1–1.5 times as long as wide, 5–8μ long; dissepiments for the most part invisible; apical cell truncate conical or rarely somewhat attenuate.

Bare and dry sandstone cliffs, not on surface of rock, but extending within the interior to a distance of at least 10–15^{mm}. Collected by Professor C. W. Hall, Sept. 28, 1896.

S. rupicola agrees with *S. Friesii* in the diameter and length of the articulations and in the shape of the apical cell; but the trichomes do not display the constriction at the dissepiments which is so evident in the latter species, nor are the dissepiments themselves so conspicuous, it being nearly impossible to observe them even under the $\frac{1}{16}$ oil immersion lens. Furthermore, it does not possess a coarsely granulate protoplasm, which characteristic Gomont proposes as a test for recognizing the species. It also differs in habitat. *S. rubella* is likewise similar in the matter of dimensions and in the non-constriction of the joints. It disagrees, however, in having distinct dissepiments, coarsely granulate protoplasm, and forming a reddish lime incrusted stratum on wet rocks. In the morphological characters of the filament, *S. rupicola* approaches *S. penicillata*, but is distinguished from it by the entirely different habit.

The plants described in this paper as inhabiting the limestone crust were collected and studied at intervals during a period of two years. I wish to thank Professor MacMillan for the help he has given me in the work.

Botanical Laboratory,
University of Minnesota.

EXPLANATION OF PLATES VII–IX.

PLATE VII.

Photograph of deposit on one of the planks from the southwest side of the tank. The crust is made up of the Dichothrix and the two Lyngbyas.

PLATE VIII.

Photograph of deposit on a plank from another side of the tank showing Chætophora thalli.

PLATE IX.

Fig. 1. Filament and pseudobranch of *Dichothrix calcarea*.

Fig. 2. Young filament of the same.

Fig. 3. Group of branches of the same.

Fig. 4. Group of filaments of *Lyngbya martensiana calcarea*.

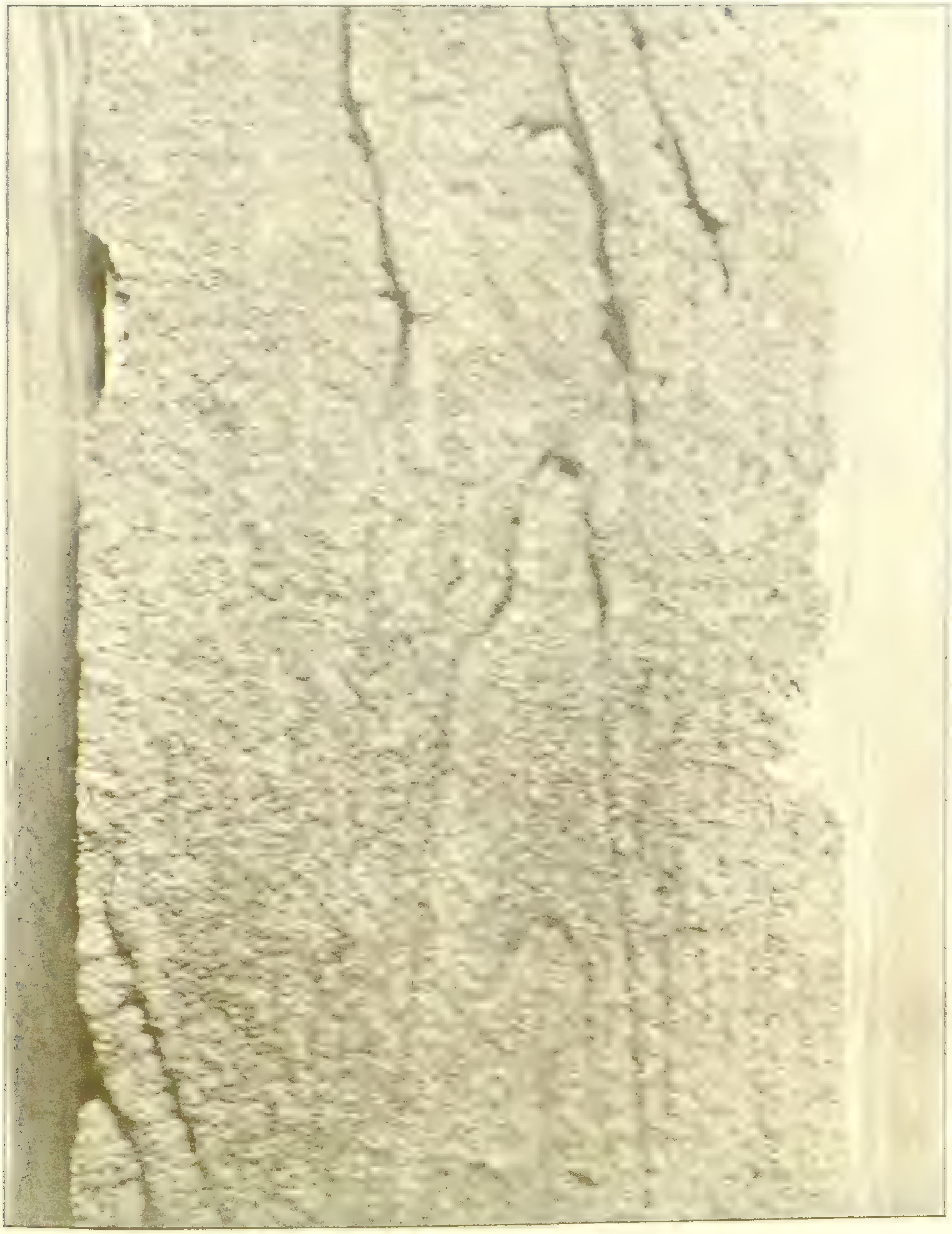
Fig. 5. Group of filaments of *Lyngbya nana*.

Fig. 6. Filaments of *Chætophora calcarea* penetrating crystal plates.

Fig. 7. Section through thallus of *Chætophora calcarea* showing arrangement of crystal plates.

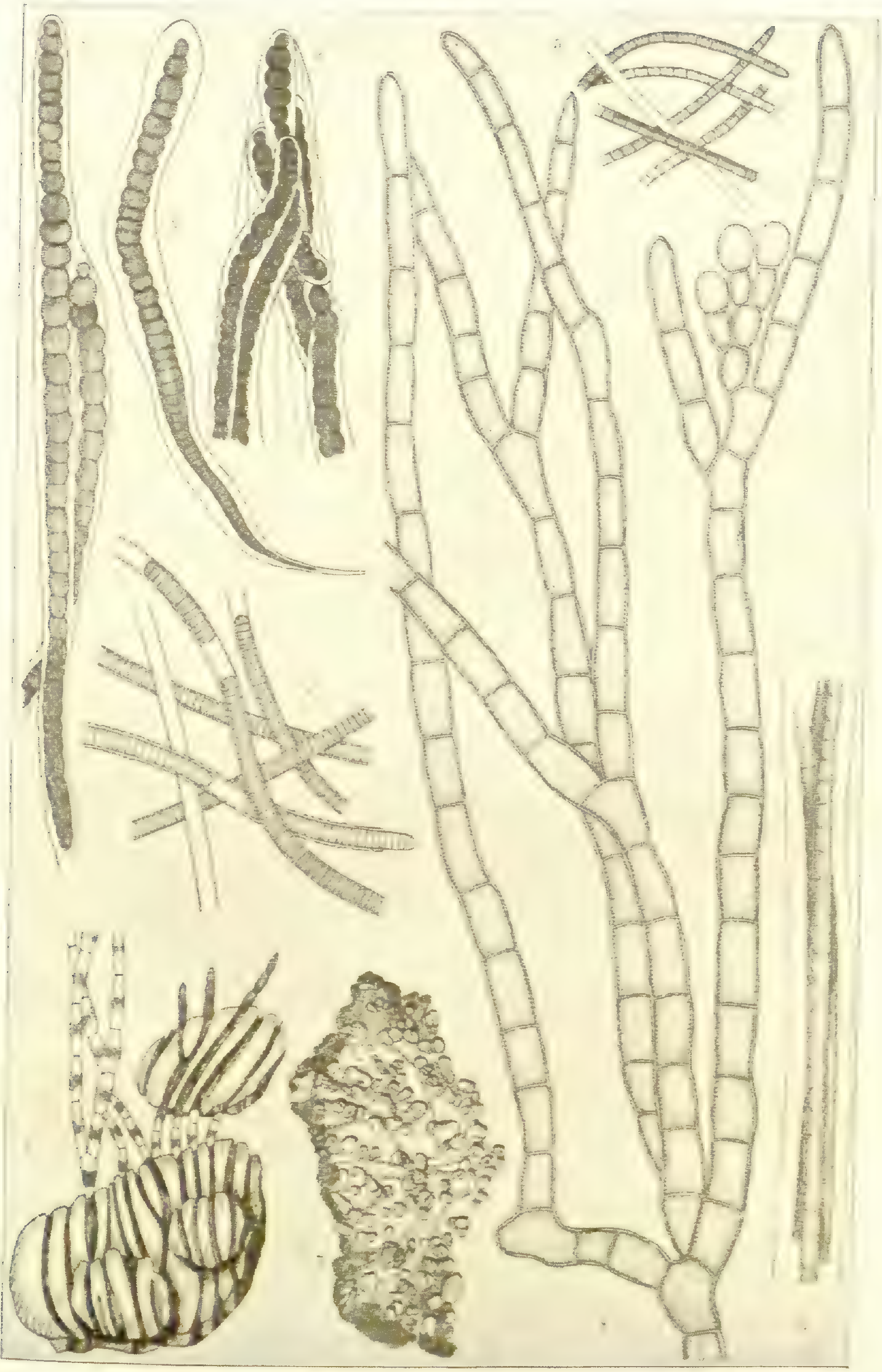
Fig. 8. Portion of a plant of *Chantransia pygmæa* showing branch bearing sporules.

Fig. 9. *Schizothrix rupicola*, with sheath containing three filaments.



TILDEN on LIME ALGÆ.

TILDEN on LIME ALGÆ.



TILDEN on LIME ALGÆ.

NOTES ON UROGLENA AMERICANA Calk.

G. T. Moore, Jr.

(with plate x)

In November 1895, at the suggestion of Dr. Farlow, I obtained specimens of the peculiar organism described by Calkins (1) as *Uroglena Americana*, and attempted to make some observations concerning it. The genus Uroglena, established by Ehrenberg (2) in 1833, referred to by Bütschli (3) and Stein (4), and considered at some length by Kent (5), has been observed in the public water supplies of Massachusetts and Connecticut with more or less regularity since 1889. In addition to the original species, Calkins (6) has found two others which he describes as *U. radiata* and *U. Americana*. Thus far I have been able to examine only *U. Americana*, and the following observations have been made upon that species.

While neither *U. volvox* nor *U. radiata* have been reported as causing any perceptible change in the water, *U. Americana* produces a very disagreeable odor, and a decided fishy oily taste. In the pond at Norwood, Mass., where all the material was obtained, the water was almost unfit for use, and caused great inconvenience. Calkins (7) seems to have successfully shown that this peculiarity of the species is due to the presence of numerous oil globules in the individual cells, and that contamination takes place through the liberation of this oil rather than from decay. The individual cells, as well as the colonies, are extremely delicate and the slightest disturbance is apt to break them up. While the water in the pond at Norwood was not noticeably disagreeable, the process of pumping it through several miles of pipe into a reservoir was sufficient to completely disintegrate the cells, and thus the reservoir water became polluted through the mechanical breaking of the colonies and cells, and consequent liberation of the oil.

THE CŒNOBIUM.

The colony of *U. Americana* presents a somewhat similar appearance to that of *Volvox globator* L. That is, it consists of a more or less spherical sac of transparent jelly, in the periphery of which are numerous green cells provided with cilia which cause the organism to rotate slowly through the water. There the resemblance ceases, and in no way can the two be said to have a generic relation.

In size and shape the Uroglena cœnobium varies greatly. While the general outline may be spherical, it is frequently found with protuberances and irregularities. All stages, from that of a perfect globe to a long cylinder with closed ends, have been observed, and many modifications of these extreme forms are apt to occur. The size varies as much as the shape. From the first early stages, consisting of but a few cells and measuring 30–40μ in diameter, we may have all gradations up to the somewhat unusual size of 525μ containing hundreds of individual cells. In the latter case the colony had been kept for some time under most favorable conditions, and probably represents the maximum growth.

The individual cells are irregularly placed, and from 10–20μ apart. There are no connecting canals as in Volvox. In regard to the structure of the interior of the colony of the original species (*U. volvox* Ehren.) there has been quite a difference of opinion. Ehrenberg (6) held that the contents were fluid, and the individual cells were drawn out into "tails," all these "tails" being united at a common point in the center of the cœnobium. Neither Stein nor Bütschli observed anything of this kind, and considered it very improbable, Stein even maintaining that the colony was a homogeneous mass of jelly from center to circumference. Kent (5) confirmed the observations of Ehrenberg in regard to the appendage of the individual cells, and suggested that they might be contractile. Zacharias (7), in a recent article, brings forward the view that *Uroglena volvox* does possess an internal network of threads or "tubes," but he further maintains that the prolongation from each individual cell is not in direct communication with the center of the colony. Instead, he finds that the interior of the cœnobium is filled with a system of dichotomously branched threads, which radiate in all directions from a common center, and near the periphery unite as a single filament with the base of the individual cell.

Coming to the condition of things in *U. Americana*, there can be no doubt that such an arrangement of threads does not exist. In fact, no prolongation of the individual cell is found in any form. Careful staining with alum hæmatoxylin (the method used by Zacharias) failed to reveal the slightest trace of any connection of the cells with the interior of the colony, and various other methods were tried with the same negative result. In addition to the test of the stains, the manner in which the colony breaks up would indicate that there is no "central binding structure," for *U. Americana* is characterized by the extreme delicacy of its colonies, and while other species will stand a reasonable amount of manipulation, this form begins to separate upon the slightest change of condition, and certainly does not assume the definite arrangement of *U. radiata*, for example. Finally, the fact that numerous protozoa swim here and there in the cœnobium without obstruction, and colonies half the size of the enclosing one are found revolving freely within, would seem to show conclusively that no network of threads, as described by Zacharias in *U. volvox*, could exist in this species.

THE INDIVIDUAL CELL.

The individual cells, which are placed in the periphery of the jelly like globe, vary slightly in size, ranging from 7–11μ in diameter. The great majority are spherical, but occasionally the end towards the center of the colony will be slightly tapering. In no case, however, do they approach the long drawn out appearance of those cells figured by Ehrenberg and Zacharias, and *U. Americana* is most definitely defined by the spherical outline of its individual cells.

Each cell is provided with two cilia of unequal length, the longer sometimes reaching 20μ, the shorter seldom more than

4μ. At the base of the cilia is found an elliptical or oblong red spot, and a well defined nucleus is located near the center of the cell. One or two vacuoles of a non-contractile character are present, and numerous oil globules distribute themselves throughout the individual. There is but one chromatophore, which is yellowish green in color. This usually clings close to one side of the cell, or may occupy the end towards the circumference of the colony. The base of the cell is sometimes filled with oil globules, but is generally hyaline. Previous to the observations of Zacharias two chromatophores were reported as being present, but he demonstrated the fact that while in *U. volvox* the chromatophore frequently assumed a spiral arrangement, which made it appear divided, there was in reality never but the one color body. In *U. Americana* there is no spiral arrangement noted, and little or no difficulty is experienced in making out the single chromatophore. When the cells are ready to divide, however, there are two chromatophores present, and this may have caused the error in former observations.

The division of the individual cell takes place in the following manner. A single cell begins to turn so that the cilia are in a plane with the tangent of the sphere, instead of at right angles. The chromatophore divides and occupies opposite sides of the cell and a new red spot makes its appearance somewhat away from the old one, but not necessarily in the place where the new cilia are to originate. At the point directly opposite that at which the old cilia are located a new pair of cilia are formed, and we then have a somewhat larger cell with two chromatophores, two red spots, and two sets of cilia at opposite sides. All of this takes place before the cell begins to elongate or divide in any perceptible manner. After the new pair of cilia is completed the cell begins to lengthen in the direction of its cilia, and in a short time an oblong cell, nearly three times as long as wide, with a pair of cilia at each end, is formed. It is now that actual division begins to take place, and it only requires a few minutes to complete the operation. Halfway between the two pairs of cilia a constriction appears, and while it extends entirely around the cell the depression is always deepest at the side nearest the periphery of the colony. Thus the pressure is greatest from that side, and consequently the halves of the dividing cell are gradually turned at right angles to their former position, and at the time when complete division takes place present their normal appearance, viz., with cilia at right angles to the tangent of the cœnobium. The red spot, which may have been in almost any part of the cell at first, takes its place at the base of the cilia before the final separation occurs. A reference to the figures will explain better than any description just how this division takes place.

THE RESTING STAGE.

Under certain conditions it is possible for an individual cell to lose its cilia and, forming a thick gelatinous wall, go into a resting stage. When this occurs the chromatophore breaks up and the chlorophyll is distributed throughout the entire cell, the red spot wholly disappearing. After a time the contents of this encysted cell divides and forms two elliptical bodies, and these in turn dividing we have four elliptical cells within the original cyst wall. Each daughter cell is provided with a red spot and a pair of cilia before the wall is ruptured, and so is ready to begin the process of division and formation of a new cœnobium as soon as liberated.

When the cells are first set free the chromatophore does not occupy the definite position that it does later, but is distributed equally throughout the contents of the cell, and is of a brighter green color. Oil globules are very abundant at this time, and give the cells a decided granular appearance. In a very few instances a cyst was observed that had divided into eight daughter cells. This was mentioned by Kent (5), but does not seem to be the general rule, and certainly is not necessary.

TAXONOMIC POSITION.

From the large number of colonies examined, and the length of time the observations covered, it would seem probable that enough negative evidence had been secured to justify our considering Uroglena as being among those forms which have no sexual mode of reproduction. It is certain that up to the present time nothing has been observed that can in any way be considered as indicating anything but the simplest methods of multiplication. Kent (5) observed bodies which he designated as "microspores" and "macrospores," but that is the most that can be said in regard to the fact. Zacharias (7) calls attention to larger cells in the periphery of the cœnobium, containing two red spots and two chromatophores, which he names "zygote formers." Since he does not describe the process of conjugation, one is led to believe that it had not been observed and, for the present at least, the term zygospore will have to be classed with the microspores and macrospores of Kent. It naturally occurs to one that the so called zygote forming cells of Zacharias were merely ordinary individual cells about ready to begin the process of division.

It would seem, then, since the only known method of reproduction is by simple division, that the taxonomic position of Uroglena, if it is to be regarded as a plant, must be among the multicellular Chrysomonadaceæ of the class Syngeneticæ.

It is so placed by Warming (8), and more recently by E. Lemmermann (9), and while the characters of the genus are hardly in accord with the family Syngeneticæ as defined by Rostafinski, still it would seem that under the generally accepted idea of the Chrysomonadaceæ Uroglena would find a place in that order, together with Syncrypta.

From the foregoing account it will be seen that *U. Americana* varies decidedly from the description of *U. volvox* as given by Ehrenberg, Zacharias, and others. The fact that the European species is found most abundantly during the summer, while here the colder months are more favorable to its growth, may account for some of the minor variations. It seems probable, however, that what has been considered *U. volvox* by previous observers has not always been the same species, and that much of the inability to agree, and the surprise expressed by more recent writers that certain structures had not been seen by former investigators, is due to this fact. According to Zacharias the cilia of *U. volvox* are more nearly of the same length, there are no vacuoles or oil globules, and the individual cells are elliptical or oblong, being invariably drawn out into a tapering point which is prolonged into a thread. On the other hand, *U. Americana*, as shown, contains no network of threads, and the individual cells are spherical in outline, not being prolonged in any way. The single chromatophore seems to be common to both species. The method of reproduction in *U. volvox* has not been satisfactorily demonstrated and no comparison can be made; however, nothing has been observed thus far, that would make it improbable that the peculiar method of multiplication as described above for *U. Americana* does not exist in the original species.

For convenience I append a somewhat modified description of this species as given by Calkins:

UROGLENA AMERICANA Calkins, 23d Ann. Rep. Mass. State Board of Health, 1891.—*Cœnobium:* irregularly spherical, varying greatly in shape and size, averaging 200–300 μ; no peripheral canals or internal network of threads; revolves slowly through the water by means of cilia of individual cells. *Individual cells:* spherical or occasionally slightly elliptical, never prolonged into an appendage at end towards center of colony; two cilia of unequal length, 15–20 μ and 2–4 μ respectively, the longer with decided undulatory motion; red spot at base of cilia and a single chromatophore, of a yellowish green color, usually occupying one side of the cell and clinging close to the wall; nucleus, non-contractile vacuoles, and numerous oil globules present.

Water supplies of Massachusetts and Connecticut. September-June.[1]

I desire to acknowledge my indebtedness to Professor Farlow for his interest and advice, also for the loan of valuable and necessary literature on the subject.

CAMBRIDGE, MASS.

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[1] Since the above went to press, Uroglena has been reported from Indiana by Mr. S. Burrage of Purdue University, and probably will be found to be widely distributed.

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EXPLANATION OF PLATE X.

Uroglena Americana Calk.

FIG. 1. General appearance of colony, × 333.

FIG. 2. Individual cell, × 2000.

FIG. 3. Individual cell with two chromatophores, two red spots and two sets of cilia, ready to elongate, × 2000.

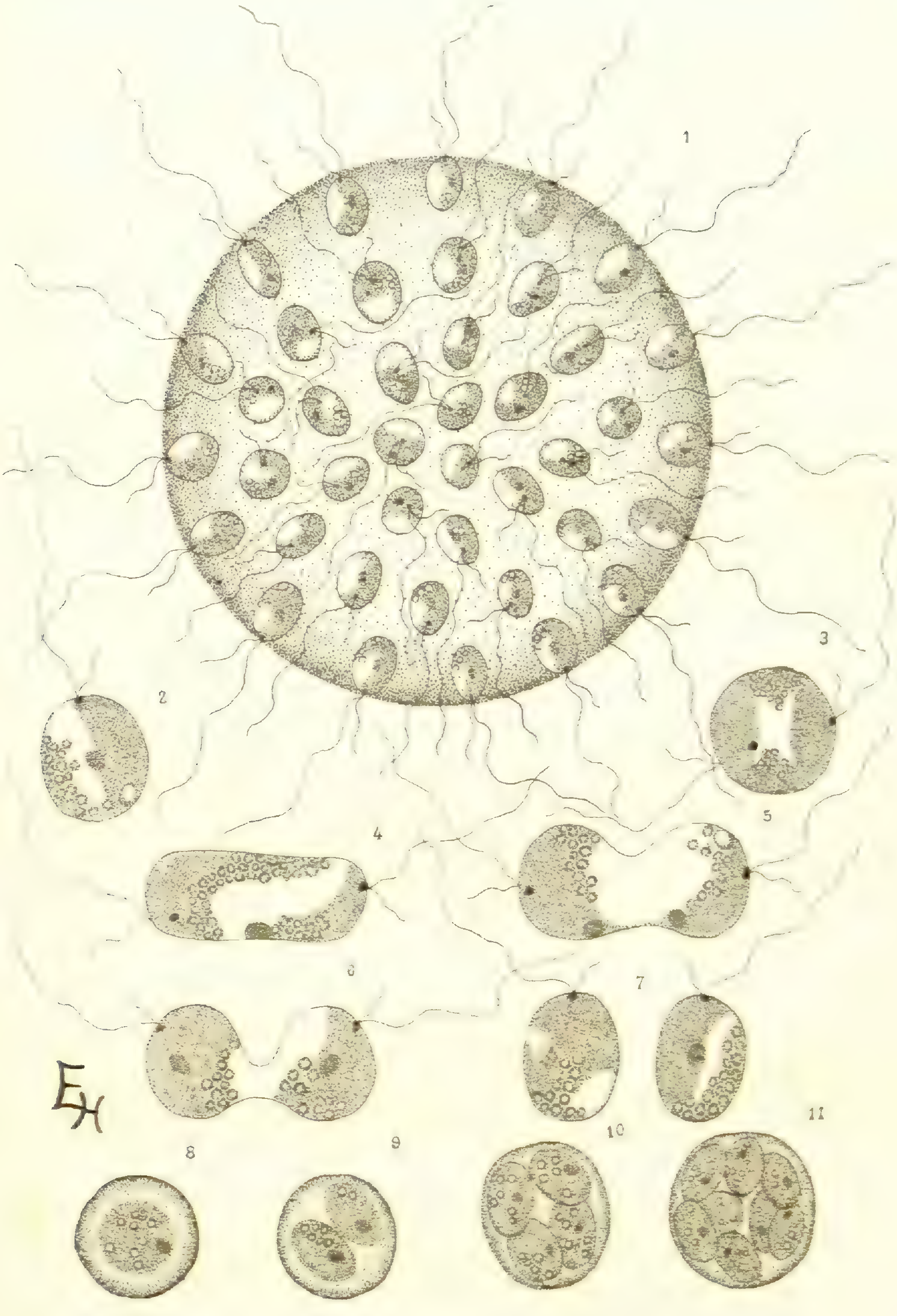
FIGS. 4–7. Successive stages in the division, showing manner in which cell turns from horizontal to vertical position, × 2000.

FIGS. 8–11. Encysted forms, × 1000.

FIG. 8. Before division.

FIGS. 9–11. Various stages in formation of daughter cells.

All drawn from nature, and as far as possible sketched with an Abbé camera.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MOORE on UROGLENA.

HYPOXIS ERECTA LINN.

A BIBLIOGRAPHICAL STUDY.

THEO. HOLM.

(WITH PLATE XI)

SOME of the numerous synonyms which have arisen from the first to the second edition of Linnæus' *Species plantarum*, and which have become a necessity to the systematic botanist to understand and recognize, appear at first glance to be rather surprising, and are well worth submitting to a closer investigation. The transferring of a generic name from one genus to another is not uncommon in the Linnean publications, but there seems to have been, at least in some cases, a good reason, if not excuse, for making a change of this kind. From a bibliographical point of view, it is often quite interesting and instructive to investigate some of these changes, and the writer has had in the present case a certain inducement for trying to discover the reason which led Linnæus to describe our amaryllidaceous genus Hypoxis at first as an Ornithogalum.

No critical or conscientious botanist should accuse Linnæus, however, of having overlooked so important a character as the position of the ovary, which is superior in Ornithogalum and inferior in Hypoxis. Linnæus was too well acquainted with such primary characters, and it was due, therefore, not so much to his own defective observation as to the misleading descriptions of previous authors, whose works were the only ones accessible to Linnæus at the time when he wrote his first edition of the *Species plantarum*. It is absolutely necessary, therefore, to admit a distinction between Linnean synonyms and *nomina nuda*, when a Linnean change of name is to be verified. The fact is that the name *Ornithogalum hirsutum*, which appears in the first edition of *Species plantarum* (p. 306), was rejected by Linnæus himself in the second edition of the same work, and simply used as a quotation for what he had thought to be a well distinguished species of Ornithogalum, instead of being a combination of two different genera. It is beyond any doubt, therefore, that Linnæus really once intended the name *Ornithogalum hirsutum* for our *Hypoxis erecta*, but his knowledge of this plant was largely, if not exclusively, based upon defective descriptions and illustrations given by earlier authors.

In order to present the Linnean quotations as complete as possible, I have thought it best to reprint here the diagnoses of the first three species of Ornithogalum, especially as the first edition of *Species plantarum* has become a very rare book. The Linnean diagnoses read as follows:

Ornithogalum.

luteum 1. *Ornithogalum* scapo anguloso diphyllo, pedunculis umbellatis simplicibus. Fl. suec. 270.
Ornithogalum scapo diphyllo, pedunculis simplicibus terminalibus, filamentis omnibus subulatis. Hort. Cliff. 124. Roy. lugdb. 31.
Ornithogalum luteum. Bauh. pin. 71.
Pyrrhochiton Reneal. spec. 91. t. 90.
Habitat in Europæ cultis macellis.

minimum 2. *Ornithogalum* scapo angulato diphyllo, pedunculis umbellatis ramosis. Fl. suec. 271.
Ornithogalum luteum minus. Bauh. pin. 71.
Hypoxis Reneal. spec. 92.
Habitat in Europæ cultis oleraceis.

hirsutum 3. *Ornithogalum* scapo angulato, pedunculis umbellatis villosis.
Ornithogalum scapo bifloro. Roy. lugdb. 31.
Ornithogalum virginianum luteum. Pet. gaz. I. t. I. f. 3.
Ornithogalum luteum parvum virginianum, foliis gramineis hirsutis. Pluk. alm. 272. t. 350. f. 12.
Ornithogalum vernum luteum, foliis angustis hirsutis. Gron. Virg. 37.
Habitat in Virginia, Canada.
Spec. 1. 2. 3. maxime affines sunt.

This last remark certainly indicates that Linnæus did not suspect *Ornithogalum hirsutum* to be generically distinct from the two other plants. His knowledge of the American plant must have been very imperfect at that time, and the descriptions given by previous authors do not differ in any respect so as to leave a doubt concerning the true relationship of our plant. They all agree in naming it Ornithogalum, even Gronovius, who undoubtedly was in possession of specimens from Clayton, who had collected the plant in Virginia.

If we compare the various quotations given above by Linnæus, we will obtain a good idea as to how much knowledge the old authors possessed of the genus Ornithogalum. The two species enumerated by Linnæus as nos. 1 and 2 were transferred later by Salisbury to his new genus Gagea (p. 553),[1] since these showed a very marked difference from the true species of Ornithogalum. We even notice that Reneaulme (pp. 91 and 92) did not consider these two species as belonging to Ornithogalum, since he gave them the generic names Pyrrhochiton and Hypoxis, the first of these containing *O. luteum*, the second *O. minimum*. The quotation "Pet. gaz. I. t. I. *f. 3*" should have been *f. 11*, since *f. 3* represents a Chiton, and *f. 11* on the same plate represents our *Hypoxis erecta*. The description[2] reads as follows: "*Ornithogalum* Virginianum luteum, foliis gramineis hirsutis nobis." "Its hairy grasslike leaves distinguish it," and the plant is said to be "common in Carolina, Maryland and Virginia."

Petiver, from whom these quotations are taken, quotes again Ray, who evidently was the first author to publish a description of our Hypoxis as "*Ornithogalum* luteum parvum foliis gramineis hirsutis." This description (**2**: 1928) was not given, however, by Ray himself, but by Banister, who had sent a catalogue to Ray, wherein he enumerated and described such plants as he had observed in Virginia.

Another old citation is that of Plukenet (Alm. bot. mantissa. 272), who like Petiver figures the plant. Comparing these two figures with each other (*pl. XI*), it is evident that they were both intended to represent *Hypoxis erecta*, but the principal characters, inferior ovary and short stamens, have not been figured correctly. Plukenet even figures a small calyx besides a 6-leaved corolla, and he has also indicated the presence of small bulblets at the base of the main bulb, as in Gagea, but which do not occur in Hypoxis. Plukenet, no doubt, made his figure from a poorly preserved specimen of Hypoxis, and he changed certain parts in order to make the drawing fit into the genus Ornithogalum. Plukenet's diagnosis in *Almagestum botanici mantissa* (p. 272) is given as follows:

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[1] The references are to books enumerated under "Bibliography" at the end of this paper.

[2] PETIVER: Decas prima **1**: *pl. 1, fig. 11*.

> "*Ornithogalum* Virginianum floribus luteis, atra macula insignitis, summo caule veluti in umbellam diffusis."

No "atra macula," however, is to be observed in the flowers of Hypoxis or Ornithogalum. We might note here, in order to give some idea of Plukenet's comprehension of Ornithogalum, that this author in his *Phytographia* (*pl. 102, fig. 3*) figures another species of Ornithogalum:

> "*Ornithogalum* affinis Virginiano, flore purpureo pentapetaloide. Banist. Cat. Msc."

This, however, represents *Claytonia Virginica!* These two figures, given by Plukenet and Petiver, seem to have been the only ones which at that time were known to Linnæus, although a third was then in existence in Dillenius' *Horti Elthamensis plantarum*. Linnæus does not seem to have known this figure (*pl. 220*) until he published the second edition of *Species plantarum*, wherein he gives the full quotation from Dillenius: "*Ornithogalum* Virginici facie, herba tuberosa Carolinesis," a plant which Linnæus named *Hypoxis sessilis*."

This plant does not differ, however, from *H. erecta*, excepting that the flowers are situated close to the ground. It is to be noted that in this figure the details of the flower are very well shown, and there is no doubt that if Linnæus had seen this figure when he first wrote the *Species plantarum*, he would have been able to discover the mistakes in Plukenet's and Petiver's two figures, and he would perhaps at that time have referred our plant to Hypoxis instead of to Ornithogalum.

The remaining Linnean quotation is that of Royen (p. 31) which is too short and incomplete, however, to give any idea of the genus Hypoxis. It is also very doubtful whether Royen really had this plant in cultivation in the botanical garden at Leyden as early as 1740, since it has been stated that Hypoxis was not cultivated in Europe until 1752, and, as far as can be ascertained, first in England. These four citations of the works by Plukenet, Petiver, Royen, and Gronovius constituted, therefore, the only literary sources to which Linnæus had access at the time of his writing the first edition of *Species plantarum*, at least so far as concerns *Ornithogalum hirsutum*. The two preceding species, *O. luteum* and *O. minimum*, were both well known to him, as he cites these from his own works (*Flora suecica* 96, and *Hortus Cliffortianus* 124). He also quotes Bauhin's *Ornithogalum luteum* and *O. luteum minus* as synonyms of his *O. luteum* and *O. minimum*, now known as *Gagea lutea* and *G. minima*. There is, therefore, some reason to believe that Linnæus had not seen Hypoxis, either in a living or dried state, and that his first specific diagnosis, so closely resembling those which he quotes, must have been merely transcribed from them with help from the illustrations before him, which did not indicate the inferior ovary and short stamens of Hypoxis. None of the descriptions with which he was acquainted differed in any essential respect from each other, or from the general understanding at that time of the genus Ornithogalum. The diagnosis in Gronovius (p. 37) was very likely the most influential with Linnæus, so far as the relationship of the plant was concerned.

The name Ornithogalum has an old history, and may be traced far back to the Greeks and Romans. Both Dioscorides (p. 541) and Plinius (**21**: chap. 62) mention an Ornithogalum with edible bulbs, but it is far from certain that their plant was identical with the genus which now bears that name. Among the earliest authors who unmistakably described not only Ornithogalum but also Gagea may be mentioned Fuchs, who has illustrated and described "Bulbus sylvestris" or "Oignon sauluaige" (p. 95); Lobelius (p. 72), who figures the same species of Gagea as *Ornithogalum luteum*, besides the true *O. umbellatum*, under the name "*O.* Leucanthemus minor," which is also described by

Dodonæus (p. 221) as "Bulbus Leucanthemus minor;" and Clusius (p. 188), who has described and figured *Gagea lutea* as "*O.* pallido flore," and another species of Gagea as "*O.* Pannonicum luteo flore." The Dillenian genus Stellaris (Cat. plant. 110) indicates the first distinction between the true species of Ornithogalum and those which Salisbury referred to his Gagea.

It appears, according to the above statements, that the European genus Ornithogalum, including Gagea, was very well distinguished before Linnæus undertook to write his *Genera* and *Species plantarum*. The rather superficial, but nevertheless quite striking, similarity between the small yellow-flowered species of Gagea (Ornithogalum of Linnæus) and the American Hypoxis made several authors from Ray to Gronovius confound these, so as to consider them all as belonging to Ornithogalum, until Linnæus himself was led to make the same mistake. Linnæus, however, corrected the mistake in the second edition of his *Species plantarum*, and his characterization of Hypoxis in *Systema vegetabilium*, "Hypoxis corolla supera," is sufficient to prove that he had obtained material finally for a correct description of the plant, inasmuch as he changed the formerly given specific name *hirsutum* to *erecta* (*Sp. pl.* 2d ed. 439). As a matter of fact, *Hypoxis erecta* is not "hirsute," but "pilose," as Linnæus later on described it. That he named it *erecta* was evidently to distinguish it from the related species *decumbens*, *sessilis*, *sobolifera*, etc., all of which are hairy; while the former specific name, *hirsutum*, would have distinguished it at once from the species of Ornithogalum, of which only a few are slightly pubescent. Furthermore, that Linnæus had not seen the plant in a living state, not even when he wrote the sixth edition of his *Genera plantarum* (1764), is evident from his marking the genus with a cross, which according to his preface means: *Crucem ubi siccas solum habere potui!* The plant Hypoxis, as stated above, was not cultivated in Europe until the year 1752, and very likely first in England. It seems, therefore, according to the preceding statements, that Linnæus had no direct knowledge of Hypoxis until he published his second edition of *Species planta-*

rum, and that his first treatment of the genus as an Ornithogalum was due to the defective diagnoses and illustrations given by his predecessors. The name *Ornithogalum hirsutum*, therefore, is a *nomen nudum*, and Linnæus should certainly not have been obliged to preserve the specific name *hirsutum* because he changed the generic. His own observation of the dried specimens, when he finally received these, showed him his mistake as to the genus and as to the character "hirsute," which is only too evident from his renewed characterization of the species as "pilose." It is evident, therefore, that *H. erecta* L. should not be set aside for *H. hirsuta* (L.) Coville.

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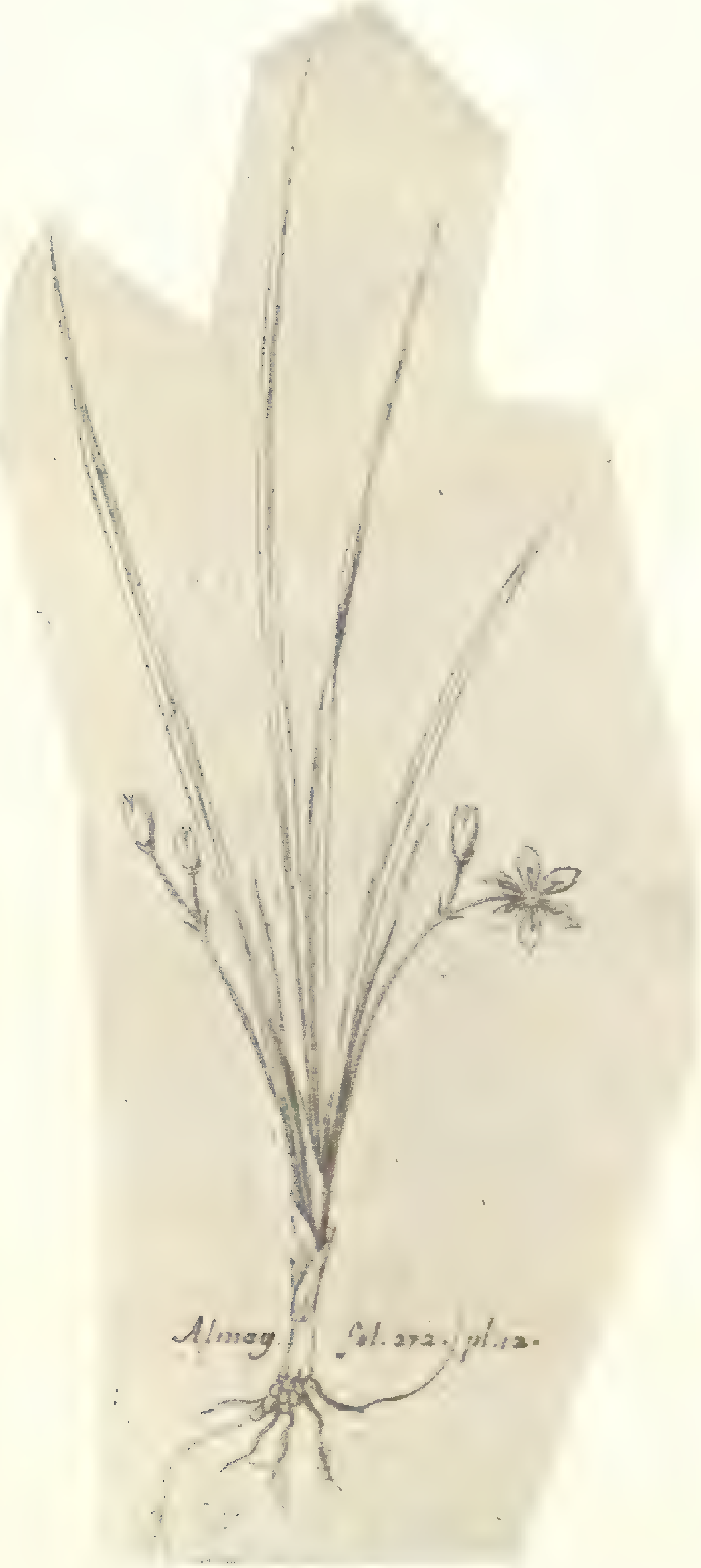
EXPLANATION OF PLATE XI.

FIG. 1. A photographic reproduction of Plukenet's figure of *Hypoxis erecta* L.

FIG. 2. A similar reproduction, but reduced one-half, from Petiver's illustration of the same plant.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HOLM on HYPOXIS.

BRIEFER ARTICLES.

ZIZIA AUREA AND THASPIUM AUREUM.

For the past two seasons special observations have been made upon these plants. Combined with those of previous years they furnish a fair outline of the habits and character of the two as they are found in those parts of Illinois and Indiana contiguous to Chicago. A large number of specimens were critically examined and compared and abundance of field notes made. Although the two plants have frequently been confounded by collectors, I find few plants so nearly allied that are better distinguished specifically, and a little practice enables one to tell them from the time the radical leaves attain a fair size in the spring.

The beginning and duration of the flowering season of the two plants differ, and still more those of the fruiting season. The ordinary season of anthesis of *Z. aurea* in this region is from the middle of May to the middle of June, while that of *T. aureum* is from the first of June up to near the middle of July, usually lasting two or three weeks longer than in the case of *Z. aurea*. The remarkably early spring of 1896, due to the summer heat of April, brought both plants forward considerably earlier, and the terminal umbel of the stem of *Z. aurea* was beginning to bloom by April 30. By the 12th of May the plants were in full flower. At the latter date all examples of *T. aureum* that were found were in bud. When next examined on the 23d of May they had come into flower, but the anthesis was principally confined to the first umbel. The fruit of *Z. aurea* begins to ripen during the first half of July, and by the last of August has about all fallen from the dead stems of the plant. I have found it clinging to the carpophore as late as September 7, but the connection was so fragile that the slightest disturbance dislodged it. The mericarps of *T. aureum* are well advanced by the first of August, and in an early season like the last some will be ripe by the last of the month, but the ordinary time of ripening is September, and nearly all of the carpels are found adhering to the rays of the umbellets then. I have found the carpels still adhering to each other as late as October 19. While the two plants differ by about two weeks in beginning their anthesis, they differ from four to six weeks in the time needed to mature their fruit. The fruit of *T. aureum* not only matures more slowly, but also adheres more firmly to the carpophores, and requires a greater force to detach it.

This later ripening and firmer attachment of the fruit evidently has a bearing on the distribution of the plants. The Zizia is seen scattered about over wide spaces in localities where it grows, while the Thaspium is apt to occur in patches or colonies. The fruit of the former is readily torn off by any slight jar given by passing animals or by the wind, and is by these means often thrown quite a distance around. The fruit ripens and the stalks die before the appearance of frost. The fruit of the Thaspium usually falls to the ground with the ripened stalk, or this may be cut down by an early frost. Its firmer attachment tends to keep it nearer by when dislodged. The seed is from these circumstances left near the parent stock, and from its mode of distribution helps to keep the plants in patches. Owing to the longer life of the plant the fruit as well as the stem and leaves frequently become purple in late summer, and quite generally so late in the season at the time of frost.

There is quite a difference in the general appearance of the two plants. The leaves of *T. aureum* are of a lighter shade of green; their texture, even when thin, rather firmer than in *Z. aurea*, and the network with larger and more open meshes. They are bordered by a white hyaline line, which often becomes prominent, especially in the lower leaves. In *Z. aurea* the network is very fine, the meshes small, the hyaline line very narrow, the whiteness often limited to the tops of the serratures, which are sharp in most cases and callous tipped. Familiarity with this leaf structure enables one to tell the plants in nearly all stages of growth, as they are quite constant. The flowers of *Z. aurea* are golden yellow, as its specific name indicates; those of *T. aureum* are paler, inclined to a lemon-yellow. The rays in the umbels of the latter contract much more on their inner side than those of the former, so that they bend inward and bring the carpels more into a bunch, and make the diameter of the fruiting umbel considerably less than that of the umbel when in flower.

Two forms of *Z. aurea* may be noted: (*a*) A wood form, growing in the woods or shady places. It is commonly the taller of the two, from three to five feet high, the radical leaves on petioles twelve to twenty inches long, the leaflets large, the terminal 2-4 inches long by 1½-3 inches wide. The leaflets are very sharply, often doubly serrate, or somewhat serrate-lobed. (*b*) A prairie or meadow form. This is usually seen in fields or in the thinly wooded sections of the sand dune region. It is a smaller plant, from eighteen inches to three feet high, the radical leaves on petioles a foot or less in length. The leaves are tinged with yellow, generally simply serrate, or the lower stem and radical leaves serrate-crenate. The fruit is essentially the same in both forms, though the carpels in (*b*) are apt to be broader than deep, a cross section approaching a circular form less nearly than in (*a*). The plants resemble *Z. cordata* more than those of the woods form, but I have not found any with cordate leaves, nor detected *Z. cordata* in our local flora.

The examples of *T. aureum* which I have seen here do not conform either to the type or to the variety *trifoliatum*. Though inclining to the variety it would be quite futile to try to draw a line of separation. The radical leaves, whether round-cordate and entire, or divided, are crenate or crenate-serrate. The cauline leaves change gradually along the stem from the basal with crenate-serrate margins to those which are serrate, the uppermost frequently quite sharply serrate. Plants with the radical leaves simple and cordate are common, but grow promiscuously with those having the radical leaves trifoliate, or both forms of radical leaves spring from the same root. A suite of radical leaves in various stages of development from the cordate to the trifoliate, or even pinnate, can easily be collected. Some are two lobed, cleft or divided, others three lobed, cleft or divided, or variously changing into subpinnate or pinnate forms. Cordate leaves are rarely absent from a group of plants. If not attached to the stem-root, a little searching reveals them as the leaves of seedlings close at hand. These are generally entire, but some have the lobation commenced. Dividing is, however, infrequent until the root is old enough to bear a leafy stem.

Sometimes the ribs of *Z. aurea* are expanded so as to make a narrow wing, and it is hardly proper to call the fruit in all cases apterous. But other characters so plainly distinguish it from *T. aureum* that the two are readily separated specifically, even if they were to be united generically. Though the terminal fruit in the umbellets of the two plants is frequently aborted, when present I have found no exception to its sessile character in Zizia and stalked in Thaspium.

As far as I have met with the two plants in this region they differ in their habitats. *Z. aurea* is very abundant, and occurs throughout in suitable localities, and grows indifferently in clayey and in sandy soils, but more vigorously in the former. *T. aureum* is infrequent, and has always been found in clayey or loamy land, and almost always along streams. I have but one specimen away from streams or the vicinity of water, from Forest Hill, in the south part of the city. Its principal home is along the bluff banks of streams, or beyond the bounds of the flood plain. From these banks, either contiguous to the stream or bordering the flood plain, it spreads a little into the adjacent woods. In such situations I have seen it by the Kankakee river, the Desplaines and some of its branches, the Calumet, and Thorn creek, one of its affluents, and it is likely to occur under similar conditions along other streams of the vicinity.—E. J. HILL, *Chicago*.

A NEW ISOETES FROM IDAHO.

Isoetes Underwoodi, n. sp.—Leaves 18–50, rather slender, 10–16^{cm} long, erect to recurved, semi-lunate or nearly helmet shaped in section, striate, with abundant stomata above; peripheral bast bundles generally all four present, but sometimes one or more lacking: macrosporangia dark brown: microsporangia olivaceous, elliptic to narrowly oblong, much pitted, 6–8^{mm} long, slightly covered by the narrow wings of the velum: ligule rather narrowly triangular: macrospores *bright white*, 0.33–0.45^{mm} thick, rough with low single or confluent tubercles: microspores 0.025–0.028^{mm} long, unsymmetrical, short spinulose on the edges.

Wet ground, borders of pools, Paradise creek, in and near Moscow, Idaho.

This plant is submerged during a greater part of the spring, but seems to reach perfection entirely out of water. The dry leaves look more or less round, but this is due to the sharp lateral edges becoming so involute as to present merely a narrow channel along the widest side. The air cavities are generally quite large and the walls thin. It differs much from the only other two species of this region, ***I. Nuttallii*** and ***I. Bolanderi.*** From the first it differs in its longer and more numerous leaves, spotted velum, bright white instead of brownish macrospores, and amphibious nature. From *I. Nuttallii* it differs in its partial, not complete velum, its usually four bast bundles, smaller macrospores, and amphibious nature.

I take pleasure in dedicating the species to Professor L. M. Underwood, to whose admirable little work, "Our Native Ferns and their Allies," I owe many an hour of profit and delight.— L. F. HENDERSON, *Moscow, Idaho.*

EDITORIALS.

The Metric System in Botany

The botanical editor of the *American Naturalist* has done well in calling botanists to account for their persistent use of the old units of measurement. We take it for granted that argument is no longer necessary to establish the claim of the metric system. As Dr. Bessey says, the scientific bodies of the country have urged upon Congress the advisability of legislating upon the subject, and are loud in their denunciation of the crudities of the old system. Among these protesting scientific men botanists are prominently represented, and it seems somewhat inconsistent for them to continue to use such measurements as lines, inches, etc. Usage is more powerful than legislation in such a matter, and the change will be effected for botanists when their standard texts and leading journals rigidly adopt it, at least in all technical descriptions. In the *Synoptical Flora*, begun so long ago, uniformity seems to demand a continuation of the old units in all subsequent parts. In so new a publication as the *Illustrated Flora* it is a pity that the metric system was not introduced. In the forthcoming *Flora of North America* it certainly should be adopted. The journals, however, can change at any time. It has been the policy of the Botanical Gazette to use the metric system in all technical descriptions, unless for some reason the author prefers the old units. We would now suggest that all American journals and serial publications unite in making the change, not in loose fashion, but as an avowed policy.

Tropical Laboratory Commission

It is somewhat remarkable that the tropical laboratory proposition should have met with so immediate and so wide a response. Mr. MacDougal's announcement of the commission within two months of the first suggestion is noteworthy, but less so than the composition of the commission. It might have been expected that this duty would find only some of our younger botanists ready, but with Dr. Farlow and Dr. Campbell as the additional American members, the commission becomes most adequately representative of American botanists. The institutional and botanical distribution of the commissioners is most happy. Their judgment will be competent to include every facility sought for in tropical surroundings, and their report will be regarded as final both as to the location and the advantages of a tropical laboratory. The assured cooperation of British botanists through a commissioner, and through liberal offers of facilities in case the station is established in British possessions, insures for the laboratory an international character.

OPEN LETTERS.

MOUNTING PLANTS FOR USE IN POPULAR LECTURES.

To the Editors of the Botanical Gazette: In winter, at our State Agricultural College, some one of the botanical department is often required to instruct students who elect short courses in grasses, clovers, other forage crops, or weeds. In like manner these subjects are often presented at farmers' institutes and agricultural fairs. Bunches or bundles of these plants are too easily damaged by handling to be of much service. I have found the following scheme for exhibiting plants on such occasions eminently satisfactory.

Procure some wire screen thirty inches wide and five or six feet long, having about four wires to the inch; fasten on one side numerous stout strips of wood an inch or more in thickness. Make a mate to this and we have a press of heroic size. With large driers and thin sheets grasses and other plants are pressed at full length. Procure some rather firm and tough manilla paper two feet wide and perhaps three feet long. For longer plants a sheet can be spliced by pasting a piece of the paper across a seam on the back. These manilla sheets of suitable length are then bound with brown or black muslin or other material neatly pasted over the edges and ends. This makes the sheets stiffer and protects the edges in transportation. The specimens are placed in suitable position and sewed fast with carpet thread of a dull green color, and where the leaves are broad fish glue is also used. Over the long stitches on the back side paper is pasted, *a la* buttons in a dry goods store, to prevent the plants from working loose in case a thread is broken.

Sew or paste on a large card containing name of plant and a few other items of importance. Two of Dennison's No. 12 spring hooks clasp the top of a sheet and hold it to a cord or thin strip of wood strung about a hall at suitable height.

To transport specimens a crate or frame is made consisting of sides only of half-inch basswood or pine nailed to three crosspieces, one by two and one-half inches. Near the end of each strip is a wire staple clinched on the side next the specimens. These staples serve to hold three strong straps to buckle about a bundle. To protect from accidental rain wrap the bundle of specimens with oilcloth before binding in the crate.

A large herbarium case is constructed, into which these long sheets are shoved sideways, each sheet having a name on each edge. Of these sheets we have at least 250 species mounted.—W. J. Beal, *Agricultural College, Mich.*

THE TROPICAL LABORATORY COMMISSION.

To the Editors of the Botanical Gazette:—The organization of the commission for the selection of a site for a botanical laboratory in the American tropics is now complete so far as the American membership is concerned, with the following representation:

DOUGLAS H. CAMPBELL, Professor of Botany in Leland Stanford University.

JOHN M. COULTER, Head Professor of Botany in The University of Chicago.

W. G. FARLOW, Professor of Cryptogamic Botany in Harvard University.

D. T. MACDOUGAL, Assistant Professor of Botany, in charge of Plant Physiology, in the University of Minnesota.

As may be seen from the above list, the commission represents the entire country geographically, as well as the more important aspects of the subject. The British members of the commission will be announced in the GAZETTE for March.—D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

A primary reader.

THE revolution which the teaching of reading has undergone in late years demands books which shall not only provide exercise for the vocal cords, but also interest the pupil and command his attention. For this reason, instead of reading selections from the great orators, poets, and dramatists before the child can possibly understand or appreciate the subject matter, classics for children form the readers of the present day. Along with the nature study there has also arisen a demand for books relating to nature which can be read in school. Various efforts have been made to supply readers containing botanical matter. We have in these pages particularly commended the two books of selections by Miss Newell, which are admirably adapted to pupils in the grammar grades. We have before us a book which is intended for the primary grades. It is *Plants and their children*, by Mrs. William Starr Dana.[1]

It is not often that the intentions of an author so happily coincide with the execution as in this book. It is written in a style that cannot but be attractive to children of the age addressed. They are introduced first to fruits and seeds, then to young plants, and later to buds, leaves, and flowers, in a series of short chapters. The matter is not only attractively presented, but, happily, it is accurate as to its facts, with very few exceptions. One error, which is a mere accident, and which every child will be able to correct, is the ascription of tendrils to the bean (p. 115). Some others occur in the physiological parts, where also there are some figures of speech which are apt to lead to misconception, as, for example, saying that roots suck in water "by means of tiny mouths" (p. 100), and that what this "broth" "really wants is *cooking*" (p. 144). Naturally, when Mrs. Dana attempts to set before her young readers the difference between plants and animals she is tempted into considering only the green plants and gives them a test which will make all fungi animals. Regarding the dodder and the mistletoe our author also leads her readers somewhat astray.

But aside from these and a few similar blemishes (which can readily be corrected in the plates) the book is the freest from error of any book of the kind that we have seen, and the author is to be heartily congratulated on the success of her work. The book is to be begun at the opening of the school year, and the lessons are so arranged as to discuss those objects which are accessible at the time when the lessons are intended to be read. The teacher is expected to have the objects themselves in the room, and if possible to have them collected by the children. We shall be much mistaken if an illustrated course of reading like this does not awaken in many a youngster a new interest in plants.

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[1] **DANA, MRS. WILLIAM STARR.—Plants and their children.** Illustrated by Alice Josephine Smith. 12mo. pp. 272. figs. 277. American Book Co. 1896. 65 cents.

The illustrations are well drawn, and add much to the value of the book. A goodly number seem to be original; a few are from Kerner, which are acknowledged; while the majority are after the well known drawings of Sprague, in Gray's text-books, and might well have been acknowledged. The illustrator has drawn the English *Viscum* instead of the American *Phoradendron*, which is the mistletoe "sold in our shops at Christmas" over the greater part of the country, though possibly the English mistletoe comes to the New York markets. *Fig. 136*, alleged to be "a seed cut across," is like nothing in the heaven above or the earth beneath, and ought to be replaced.

Besides being suitable for schools this is the kind of book for which many parents are looking to put into the hands of their children, or to read with them in the home. Botanists are often asked to recommend such books, and there is now one which can be named to inquirers without misgivings.—C. R. B.

The nucleus.

THE recent extensive studies upon the cell nucleus have produced a voluminous literature regarding it. About three years ago a general and very brief summary of this literature was published by Dr. A. Zimmermann.[2] The same author has now brought together this and more recent scattered information, with critical sifting, to form a work upon the morphology and physiology of the cell nucleus.[3] In the general part he thus discusses methods of research, nomenclature, distribution, number, size, and form of the nucleus, its chemical composition, the structure of the resting nucleus, division, fusion, and physiology. In the special part the present state of knowledge regarding the nuclear phenomena of each of the larger groups of plants is given, with especial reference to reproductive processes.

How voluminious is the literature thus critically examined is probably not appreciated except by those who have given special study to cytology. The main phenomena regarding the nucleus are much alike in plants and animals, and Zimmerman has confined himself to pointing out the relations between the zoological and botanical researches. Though he therefore does not cite any very large number of the zoological papers, the list in the bibliography embraces almost 600 titles!

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[2] Beihefte zum Bot. Cent. **3**: 206, 320, 401. 1894.—**4**: 81. 1895.

[3] ZIMMERMANN, A.—Morphologie und physiologie des pflanzlichen Zellkernes. Ein kritische Literaturstudie. 8vo, pp. viii + 188. figs. 84. Jena: Gustav Fischer. 1896. *M* 5.

We are glad to observe that due notice has been given to the papers by American botanists, among whom may be noted Campbell, Humphrey, Davis, Chamberlain, Schaffner, Harper, Fairchild, Halsted, and Mottier.

This book will be needed in every library, and will be of great assistance to every teacher. It is well illustrated from drawings made chiefly by the author's wife.—C. R. B.

MINOR NOTICES.

MR. JAMES M. MACOUN has recently distributed three contributions to the knowledge of the Canadian flora.[4] The first two cited contain additions to the Canadian flora, additional stations, and the revision of names in accordance with recent monographs. The Labrador list is compiled from all available lists and specimens, being tabulated so as to show the distribution of each species.—J. M. C.

A SECOND CONTRIBUTION[5] to the flora of Yucatan has been issued from the Field Columbian Museum. It includes plants collected by Dr. G. F. Gaumer in 1895, Sr. Porfirio Valdez in 1896, and the author in 1887 and 1895. The contribution adds 120 genera and 272 species to the recorded flora of the peninsula, among which are a new genus (*Setariopsis* Scribner, founded upon *Setaria auriculata* Fourn. and *S. latiglumis* Vasey), and thirteen new species (Agaricus, Asterina, Pestalozzia, Selaginella, Peperomia, Cracca, Argithamnia, Croton, Euphorbia, Pedilanthus, Quararibea, Corallocarpus). So far as recorded 527 species are known from the mainland, and 315 from the contiguous islands. It is interesting to note that Leguminosæ head the list with 100 species, Compositæ following with seventy, Euphorbiaceæ with fifty-two, the remaining families dropping below thirty.—J. M. C.

MR. E. B. ULINE has just published an account of the Mexican and Central American species of *Dioscorea*,[6] being the result of studies at the University of Berlin. Thirty-nine species are included, eleven of which are new. Five new varieties also are defined and various specific reductions indicated. It would seem that the genus was sadly in need of revision, as are probably most of the Mexican and Central American genera.—J. M. C.

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[4] MACOUN, JAMES M.—Contr. Herb. Geol. Sur. Can. VIII and IX. Reprint from Can. Rec. Sci. Oct. 1895, Jan. and Apr. 1896. List of the plants known to occur on the coast and in the interior of the Labrador peninsula. Ann. Rep. Geol. Sur. Can. **8**: 353–356.

[5] MILLSPAUGH, CHARLES FREDERICK.—Contribution II to the coastal and plain flora of Yucatan. Field Columb. Mus. Bot. Ser. **1**: 277–340. *pl. 8–21*. D. 1896.

[6] ULINE, EDWIN B.—Dioscoreae mexicanae et centrali-americanae. Engler's bot. Jahrb. **22**: 421–432. 1896.

MR. GEORGE MASSEE has done excellent service to mycology in his redescriptions of Berkeley's types of fungi.[7] Berkeley's magnificent collection was presented to Kew in 1879, and illustrates his mycological publications from 1836 to 1885, containing over 11,000 species, among which are 4866 types. The earlier diagnoses were brief and superficial, and not at all adequate for the present demands. Mr. Massee has drawn up full descriptions, with figures, of Berkeley's types, using in every case the actual specimens originally employed by the author. About 115 species are thus described, over eighty of which belong to the genus *Peziza*.—J. M. C.

IN 1886 Professor Charles R. Barnes published a key to the genera of mosses recognized in the Manual of Lesquereux and James, which proved to meet a want of the bryologists. In 1890 he published keys to the species of mosses recognized in the same work, including descriptions of those published since the issue of the manual. Taxonomic work among North American mosses since 1890 has been so very active that a new presentation of North American material seemed justified. Accordingly a third edition of the "Analytic Keys"[8] has just appeared, which is intended also to stimulate the study of mosses during the time which must precede the publication of the new manual. The appendix to the Keys contains descriptions of species and varieties, 603 in number, published since the issue of Lesquereux and James' Manual in 1884, and before January 1, 1896. It is only upon the massing of these descriptions that one begins to appreciate the recent rapid development of our knowledge of the North American moss flora. The author feels compelled to call special attention to the large number of new species described by Dr. N. C. Kindberg, and by Dr. C. Müller in collaboration with Kindberg, from the Canadian collections of Mr. John Macoun, stating that there is good reason to believe that a majority of these are not well founded. In this view he seems to be sustained by other bryologists, and it is certainly unfortunate that such a mass of names has been injected into our synonymy, names which in many cases it is impossible to identify. Such a large amount of new material has necessitated extensive readjustment of the keys, which even then could not be made to include all published diagnoses. The author has wisely avoided the making of new combinations or the publication of new species, thinking it better that this compilation should not be cited in the future literature of taxonomy. For convenience, therefore, Renauld and Cardot's *Musci Americæ Septentrionalis* has been used as a basis, without any intention of expressing adherence to its nomenclature. Although the author emphasizes the fact that this work is a compilation, and does not regard it as of importance enough to be cited, and even feels compelled to apologize for it, nevertheless it represents such a critical insight of the group that bryologists will welcome it as both useful and important.—J. M. C.

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[7] MASSEE, GEORGE.—Redescriptions of Berkeley's types of fungi. Jour. Linn. Soc. Bot. **31**: 461–526. *pl. 16–18.* 1896.

[8] BARNES, CHARLES REID.—Analytic keys to the genera and species of North American mosses. Revised and extended by Fred DeForest Heald, with the cooperation of the author. Bull. Univ. Wis. Science Series **1**: 157–368, 1897. $1.00.

MR. RAYNAL DODGE has issued a small manual of the pteridophytes of New England,[9] which will prove of service to New England students of the group. Following each one of the eight families is a brief account of the literature, and in the case of Isoetaceæ a considerable discussion of the taxonomic characters and the best methods of their recognition are given. A new Isoetes is described, *I. foveolata* A. A. Eaton; while some bibliographical confusion has been developed for *I. Eatoni* Dodge. In the manual before us this latter species appears as "n. sp.," while it is fully published, with plates, as a new species, in the BOTANICAL GAZETTE for January last. As Mr. Dodge's manual bears the date 1896, and the publication of the GAZETTE bears the date January 1897, ordinary usage will cite the former as the place of original publication, although the two publications are really synchronous, and the intention was to have the GAZETTE publication stand as the original one. —J. M. C.

THE THESIS of Edwin B. Copeland for the degree of doctor of philosophy, presented to the University of Halle and separately published, has been distributed. Dr. Copeland's subject is the influence of light and temperature on turgor. His experiments are thus summarized: 1. The turgor of the roots is not influenced by the illumination of the shoot. 2. Plants deprived of CO_2 show generally the same turgor as those which can assimilate. 3. In organs elongating in darkness turgor is lower than in control cultures, but it remains constant after growth ceases. No influence is exerted by the supply of food, whether abundant or not. 4. In those organs whose growth is less than normal under etiolation, the turgor is as high as usual or higher. 5. If plants are brought from light into darkness the turgor of the already grown parts is not altered in any characteristic manner with relation to the environment; but if the transfer be in the opposite direction a slow reaction of turgor of the stems is observable. From these experiments he concludes that the amount of turgor of roots, stems, and leaves is only remotely dependent on assimilation, and the substance which produces turgor cannot be used even to prevent the death of the plant from starvation. The various conditions of temperature or illumination which affect growth affect the turgor in exactly the opposite manner, so that if growth is retarded turgor rises, if growth is accelerated turgor falls. Turgor is regulated by, rather than regulates, the rapidity of growth.—C. R. B.

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[9] DODGE, RAYNAL.—Ferns and fern allies of New England. 16mo., pp. viii + 52. Willard N. Clute & Co., Binghamton, N. Y. 1896.

THE SEMI-ANNUAL REPORT of Schimmel & Co.,[10] for October 1896, gives special attention to the following topics: Almond oil, which is used extensively to perfume cocoanut oil soaps, is more certain to produce a white soap which will not discolor if it is free from hydrocyanic acid; otherwise most careful attention to temperatures is requisite in the process of manufacture and drying.——The regions of China yielding cassia oil have recently been traversed by O. Struckmeyer, and a map shows their location, which is chiefly in Kwang-si and Kwang-tung, south of the Si or West river, along the parallel of 23° N. and between 110° and 112° E. The oil is distilled from about 70 per cent. of leaves and 30 per cent. of twigs.——Bergamot, lemon and orange oils are discussed, especially in relation to adulterations.——Some interesting figures are given of the peppermint crop in the states of Michigan, Indiana, and New York, which will produce this season nearly 200,000 pounds of oil, of which Michigan produces about two-thirds. The largest peppermint field in the world is in Allegan and Pearl counties, about a mile long. ——The rose fields for which this firm is famous yielded the past season 265,000 kilos of roses, representing about 60 kilos of pure rose oil.—C. R. B.

NOTES FOR STUDENTS.

THE EARLIEST general presentation of the Caryophyllaceæ, that of De Candolle's *Prodromus*, can claim little merit. In fact, it is hard to say whether the treatment of the Alsineæ by Seringe, or of the genus Silene by Otth, shows the greater haste and superficiality. Far more scholarly was the work of Fenzl, who, in his admirable treatment of the Russian and Siberian Alsineæ, in his contributions to Endlicher's *Genera*, as well as in scattered and unfortunately fragmentary papers, shows the first critical insight into the order. Since the time of Fenzl, the most noteworthy contributors to our knowledge of the Caryophyllaceæ have been Rohrbach, Boissier, and Williams. Of these Rohrbach, during his short but active life, completed masterly monographs of Silene and Melandryum, and also prepared the Caryophyllaceæ for the *Flora Brasiliensis*, while Boissier in his *Flora Orientalis* has given very full and accurate descriptions of the numerous Mediterranean and oriental Caryophyllaceæ, his treatment of Silene being especially noteworthy. Of all living writers, however, Mr. Williams has doubtless the broadest knowledge of the order, and his long expected monograph[11] of its most difficult genus is a very welcome addition to botanical literature.

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[10] Fritsche Bros., Leipzig and New York.

The work, which fills nearly 200 octavo pages and recognizes 390 species, is regarded as supplementary to Rohrbach's *Monographie der Gattung Silene*. Species fully treated by Rohrbach are not redescribed, but only enumerated with brief bibliography. Species of later date, however, are well characterized in Latin. In its scientific aspect the work is decidedly British. The species and varieties are of the Benthamian sort, and there is no attempt at the elaborate varietal and formal subdivisions popular with and sometimes inordinately multiplied by continental monographers. Unfortunately *exsiccati* are not cited, which is a considerable defect. Surely the enumeration, under each species and variety, of a very few authenticated specimens would have added much more to the value than the bulk of the work.

One of the most interesting features of Mr. Williams' monograph is the attempt to transfer from Silene to Melandryum a considerable number of American and Asiatic species, chiefly those of Watson, Franchet, and Maximowicz. Recognizing the close affinities of certain large-flowered Silenes to species of Lychnis of the *L. dioica* type, various continental botanists have, since the beginning of the century, sought to unite them as an independent genus, Melandryum, or, as originally spelled, *Melandrium* Röhl. Various combinations of inconstant characters have been devised to limit this natural but ill-defined group, the strongest being the greater inflation of the calyx and the complete absence of the partial septation usual in the capsules of Silenes. While restricted as by Rohrbach to such species as *S. Baldwinii*, *S. Virginica*, etc., the genus Melandryum seemed to have, as to its American representatives, a tolerable habital unity, which gave it a certain *raison d'être*. Mr. Williams, however, by giving up all distinctions except the septation of the capsule, and attempting to apply this consistently, feels himself forced to transfer to Melandryum also a number of species of the characteristic Eusilene type, such as *S. Palmeri*, *S. Lemmoni*, *S. Bernardina*, *S. platyota*, *S. Shockleyi*, and *S. Thurberi*. Large genera, however, are seldom satisfactorily separated upon a single technical character wholly unsupported by habital or geographic differences, and such a separation seems especially ill advised when based, as in this case, upon the presence of a structural survival such as these partial septa, which exhibit all stages of obsolescence. But even if the desirability of such a generic distinction were admitted, the writer could not agree with Mr. Williams in excluding from Silene *S. Lemmoni* and *S. Bernardina*, both of which sometimes exhibit the partial septa, which, on the other hand, are sometimes wanting in *S. multinervia*, a species which Mr. Williams without hesitation retains in Silene. It may be noted that the tricarpellary Melandryum of Mr. Williams differs materially in its limitation from the genus of Röhling, Rohrbach, Garcke, and other continental writers.

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[11] WILLIAMS, FREDERIC N.—A revision of the genus Silene. Jour. Linn. Soc. **32**: 1-196.

Considering the extent of his task and the great number of forms treated, Mr. Williams has described few new species, and those made appear to rest upon strong characters. A few changes of name, which affect our North American species, may be noted. In *S. campanulata* Wats., Mr. Williams takes the commoner broad leaved form as the species and relegates the real type to a new made var. *angustifolia*, a sort of transfer which, if generally practiced, would lead in the end to a very indefinite varietal nomenclature. For, if the type of a species is to be taken, not as that form which was originally described, but that which any subsequent writer may (from abundance of material in his own herbarium or the statement of others) regard as the commonest, agreement will be difficult indeed. The name *S. Cucubalus*, restored by Rohrbach and to be accepted by strict followers of the "Kew rule," is rejected on a combination of what would seem very weak grounds; first, Cucubalus is a generic name, although *S. Armeria* is kept up without question. Then *S. Cucubalus* is said to be pedantic; why more so than various other longer and less euphonious binomials retained, does not appear. Furthermore, it is stated that there is a name, *Cucubalus inflatus* Salisb., three years older than *S. Cucubalus*. What this has to do with the case, it is difficult to understand, for being under another genus this cannot come under the "Kew rule," and if Mr. Williams adopts the continental practice of taking up the earliest specific name, he must be aware that in this case there are earlier ones than that of Salisbury. Finally, the doctrine of usage is brought in to support *S. inflatus*, yet Mr. Williams does not hesitate at another point in his work to replace the well known North American *S. verecunda* by *S. Behrii* Williams, an elevated varietal name never current in any flora.

In the arrangement of species it is hard to see why *S. monantha* Wats., which, if not actually a variety of *S. Douglasii*, must be a near ally, is relegated to § GASTROSILENE, with which it has no close affinity. In a preliminary paper upon the North American Sileneæ, the present writer some years ago suggested that *S. purpurata* Greene, of which no authentic material was then at hand, "appeared to be near *S. Scouleri*." It is accordingly a surprise to find *S. purpurata* placed under *S. Scouleri* "*ex* B. L. Robinson," while as a matter of fact the type of *S. purpurata*, kindly loaned by Professor Greene, has proved on examination identical with the Siberian *S. repens* Patr. *S. Hallii* Wats., upon which (together with the ill-starred *S. purpurata* Greene) Mr. Williams bases his *S. Scouleri* var. *costata*, differs from *S. Scouleri* in range, habit, and inflation of the calyx, so that its specific separation by Dr. Watson seems fully warranted.

In giving geographic ranges in the New World, Mr. Williams is, to put it mildly, very un-American. For instance, to *S. Menziesii* the following extraordinary habitat is assigned: "The mountains of N.-W. America from Oregon Territory; Vancouver's Island, the Rocky mountains, and the Black Hills as far as Slave Lake; and in the United States from Vancouver's Island to Colorado, South California, and New Mexico." *S. Scouleri*, however, seems to have received a still more remarkable range, its *northern* and *western* limits being given as Vancouver's Island and British North America, and its *eastern* and *southern* limits as the Caucasus. The writer would express some doubt as to the identity of the Asiatic specimens, but even if this point is waived, it is still evident that Mr. Williams has gone around the world the wrong way! A similar lapse of clear thought is shown by the highly infelicitous name "subacaulescens" for a somewhat caulescent form of the usually stemless *S. acaulis.*

However, the few points for criticism here enumerated, and some others which might be mentioned, affect only a small part of this generally admirable paper, and Mr. Williams is to be congratulated upon the completion of a difficult monographic task and the production of a useful work abounding in clear distinctions and excellent descriptions.— B. L. ROBINSON, *Harvard University*.

MR. W. C. WORSDELL has studied the anatomical structure of the stem of *Macrozamia Fraseri*,[12] a genus which has not been investigated heretofore. Our previous information concerning the stem structure of cycads has been derived from studies of the genera Cycas, Encephalartos, and Stangeria. In these genera certain so-called "anomalous" structures were discovered which have excited considerable interest, especially in view of their possible phylogenetic significance. The examination of a single old decaying stem of a single species of Macrozamia may not form a proper basis for much safe generalization, but Mr. Worsdell has found enough in it to be worthy of record. A striking feature of the stem structure is the occurrence in the pith of a dense network of vascular bundles, a condition of things heretofore recorded only in Encephalartos. This anastomosing system traverses the pith in every direction, the course of each bundle apparently being determined by the fact that it is a constant attendant of a mucilage canal, which is a branch of a similar anastomosing network of mucilage canals. The orientatation of these vascular bundles is by no means regular with reference to the periphery of the stem, but is determined by the mucilage canals, toward which the phloem is constantly directed. As the canal twists and bends through the pith the bundle accompanies it, appearing first on one side and then on the other, sometimes giving rise to curious contortions of the vascular elements. Certain smaller branches of this vascular network were observed to enter the medullary rays and pass outwards, accompanying mucilage canals, the xylem and phloem elements joining the corresponding regions of the primary zone, the mucilage canals passing on to join the canal system of the cortex. As would be expected, this vascular system of the pith is strictly cauline, the mucilage canals appearing unattended near the apex, while farther down the accompanying vascular elements are gradually differentiated.

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[12] Ann. Bot. 10:601–620. *pl. 27, 28.* 1896.

Another cycadean peculiarity, known heretofore in Cycas and Encephalartos, is the occurrence of a succession of secondary zones of vascular strands outside of the primary leaf-trace zone, formed by successive meristem zones developed in the pericycle. In Macrozamia these secondary zones are strongly developed, the first one being as prominent as the normal one, the subsequent ones rapidly diminishing in size. The strands of the secondary zones have the same orientation as those of the primary zone, the xylem of each zone abutting almost directly upon the phloem of the next inner one. What Mr. Worsdell apparently regards as a capital discovery, however, is the detection of an occasional "tertiary cambium," by which he means that between the primary and first secondary zones, or between successive secondary zones, small intermediate bundles are occasionally developed. The remarkable thing about them, however, is their reversed orientation, the xylem being directed outwards, towards the xylem of the outer zone. This position occasionally results in an appearance so suggestive of a concentric bundle that the author associates with it the well known cortical concentric bundles of Cycas, and suggests a possible method of the derivation of the collateral bundle from the concentric. He sees in these "anomalous structures" of cycadean stems the "remnants of some ancient structure once common to a large group of plants," this ancient structure consisting of "rings or layers of concentric vascular strands." Later, the meristem of the inner portion of each concentric strand gradually became less and less functional, that of the outer portion became more and more active, and the collateral bundle was developed. These rings of ancient concentric bundles are still seen in the cortex of Cycas, and the reduced inner portions of the concentric bundles are seen in the small intermediate bundles of Macrozomia with reversed orientation. This hypothesis will be tested, not only by further examination of living cycads, but also by an investigation of the structure of numerous fossil forms which are either cycads or show cycad affinities.—J. M. C.

DR. D. H. CAMPBELL a year ago described in this journal[13] a new genus of liverworts, to which he gave the name *Geothallus tuberosus*. It is a low type, and agrees with Sphærocarpus more nearly than with any other known form. These two genera, along with Riella and Thallocarpus, constitute the lowest group (Anelatereae) of the anacrogynous Jungermanniaceae, all agreeing in the absence of perfect elaters, which are replaced by thin-walled chlorophyll-bearing cells. Dr. Campbell has now published an account[14] of the development of his new genus, showing that it agrees with Sphærocarpus in the form of the apical cell and in the general position and structure of the sex organs, particulars in which both genera resemble Riccia; and that it differs from it in its much more massive thallus, in its second division in the antheridium and the massive stalk of that organ, in its sessile archegonium and consequent deeper penetration of the foot of the embryo into the thallus, in the large size and complete separation of the smooth spores, and in the development of true leaves and tubers. In the judgment of the author Sphærocarpus remains the most primitive type, and Geothallus is intermediate between it and forms like Fossombronia.—J. M. C.

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[13] BOT. GAZ. 21:9–13. *pl. 2.* 1896.

THERE HAS BEEN much discussion as to the origin of the droplets of sweet secretion which fall from trees in midsummer, sometimes in such abundance as to cover the pavements, and especially the twigs and lower leaves. In 1884 Boudier concluded that it was wholly of animal origin. In 1891 Büsgen in his important memoir on honeydew seemed to support this view, though he discussed only the sweet secretion produced by insects. But various botanists, apiculturists, and entomologists had pointed out clearly a twofold origin of honeydew. M. Gaston Bonnier has reinvestigated the question both by observation and experiment. He comes to these conclusions.[15]

Honeydew, while more commonly the product of Aphidæ and Coccinellidæ, is also of plant origin, as may be demonstrated by direct observation of the sweet droplets as they appear at the stomata. The animal honeydew appears during the day, the plant during the night, with a maximum at daybreak. The conditions which favor its production are cool nights and hot dry days. Increased moisture in the air and cloudiness also favor it, other things being equal. Severed branches plunged in water, with the leaves shaded and in a saturated atmosphere, will produce honeydew at the stomata, even when those on the tree are not doing so. The plant honeydew approaches in chemical composition more nearly the nectar of flowers than it does that of aphides.—C. R. B.

THE Protophyta have received a new systematic treatment, the result of recent study by Professor C. E. Bessey.[16] He divides them into the two orders Cystiphoræ and Nematogenæ, composed of unicellular and filamentous forms respectively. Further, the "bacteria" are not considered a distinct family, the author not regarding the hysterophytic habit, as contrasted with holophytic, of so great taxonomic value as differences of structure. Green and colorless species should in some cases be put together, even within the limits of the same genus, as the author does in the case of Schizothrix, for example. Six families are recognized, the "bacteria" occurring in three of them, but the great majority are included in the second, the Oscillariaceæ.—J. G. C.

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[14] Ann. Bot. **10**: 489–510. *pl. 24, 25.* 1896.

[15] Revue général de Botanique **8**: 1–22. 1896.

[16] The systematic arrangement of the Protophyta. Amer. Nat. **31**: 63. 1897.

In the continuation of his studies upon flowers and insects,[17] Mr. Charles Robertson has presented results obtained from investigations of Hepatica, Asimina, Podophyllum, Solea, Euonymus, Æsculus, Astragalus, Stylosanthes, Gymnocladus, Spiræa, Gillenia, Viburnum, Symphoricarpos, Aster, Silphium, Heliopsis, Rudbeckia, and Cacalia.

In this same connection it may be noted that Mr. J. Lloyd Williams[18] has called attention to the intoxication of bumblebees by the nectar of certain "capitulate" plants (Centaurea and Carduus), and suggests that their helpless rolling covers them effectually with pollen, which upon their recovery is carried to other heads.—J. M. C.

Items of taxonomic interest are as follows: Mr. E. B. Uline has published a revision of the Mexican and Central American species of *Dioscorea*.[19] Mr. George Massee has redescribed many of the Berkeley types of fungi.[20] Mrs. E. G. Britton has enumerated[21] the Bolivian mosses collected by H. H. Rusby in 1885–6, among which are 42 species either new or previously undescribed. Mr. E. P. Bicknell has published an account of the North American species of *Agrimonia*,[22] in which he shows that *A. Eupatoria* L., not known as an American plant, has long given its name to a group of related species, five of which he characterizes, reviving old names in every case excepting for *A. Brittoniana*. Dr. T. F. Allen has described three new species of *Nitella*,[23] two from Japan, and one from Indian Territory. Professor E. L. Greene, in his last fascicle of studies,[24] discusses *Cardamine* and *Dentaria*, suggesting a new definition of the genera; proposes a new cruciferous genus, *Schœnocrambe*, based upon plants that have been referred variously to Nasturtium, Sisymbrium, and Erysimum; considers the generic name *Erysimum* untenable and substitutes for it the name *Cheiranthus*, renaming the species; discusses further the acaulescent violets; and constructs two new asteroid genera of Compositæ, *Oreastrum* and *Leucelene*, the latter founded upon *Diplopappus ericoides* T. & G. Dr. E. Koehne has published an account of the genus *Philadelphus*,[25] of which thirty-three species are recognized, twenty of which belong to the flora of North America and Central America. A new species from Mexico is described, and two from "western North America," while *P. grandiflorus* of American authors is identified with *P. latifolius* Schrad. The species hybridize freely, and a large number of such cases is recorded. Mr. William Fawcett has published a synoptical arrangement of the Melastomaceæ of Jamaica,[26] a family represented by eighteen genera and over fifty species. M. A. Franchet continues his publication of numerous new species of Chinese Compositæ, among which there recently appears a new genus, *Stereosanthus*,[27] apparently intermediate between Inuloideæ and Senecionidæ. A new Californian *Trifolium* has been described by Mr. W. C. Blasdale.[28] Dr. W. A. Setchell has published a second fascicle of his "Notes on Cyanophyceæ."[29] A plate and an account of *Sisyrinchium Californicum*, growing in Ireland, has been published by Mr. A. B. Rendle.[30] Students of fresh water algæ will welcome the appearance of the first installment of Welwitsch's African collection, by W. West and G. S. West,[31] among which are numerous new species. Mr. L. H. Pammel and Professor F. Lamson-Scribner have published notes upon a collection of grasses collected in 1895 between Jefferson, Iowa, and Denver, Colo.[32] Mr. L. H. Pammel has also published some notes upon the flora of western Iowa.[33] Mr. F. L. Fernald has published an account, with plate, of *Aster tardiflorus* L.,[34] previously discussed by him in this journal.[35]—J. M. C.

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[17] Trans. St. Louis Acad. Sci. **7**: 151–179. 1896.

[18] Jour. Bot. **35**: 8–11. 1897.

[19] See under MINOR NOTICES, p. 132.

[20] See under MINOR NOTICES, p. 133.

[21] Bull. Torr. Bot. Club **23**: 471–499. 1896.

[22] Bull. Torr. Bot. Club **23**: 508–523. *pl. 282–283*. 1896.

[23] Bull. Torr. Bot. Club **23**: 533–536. *pl. 284–286*. 1896.

[24] Pittonia **3**: 115–149. 1896.

AT ONE TIME the anatomical changes induced in climbing organs by the pressure of the support, and the pull exerted by the weight of the plant, were supposed to be coincident or causal to curvature, instead of consequent upon it. Tendrils, climbing branches, climbing hooks, and twining stems have been previously examined, and Dr. von Derschau has recently extended the work to include a number of twining petioles.[36] Twining petioles are not so highly irritable as tendrils, though they approach the less sensitive forms in sensitiveness. Petioles of Tropæolum encircled a support in five hours, Lophospermum in eleven hours, Clematis and Solanum in fourteen hours. The contact curvatures are often opposed by the heliotropic reaction of the leaf. Under such conditions a petiole of Lophospermum consumed forty hours in encircling a support.

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[25] Gartenflora **45**: 450–461. 1896.

[26] Jour. Inst. Jam. **2**: 268–277. 1896.

[27] Jour. de Botanique **10**: 384. 1896.

[28] Erythea **4**: 187. 1896.

[29] Erythea **4**: 180–184. 1896.

[30] Jour. Bot. **34**: 494. 1896.

[31] Jour Bot. **35**: 1–7. 1897.

[32] Proc. Soc. Prom. Agric. Sci. 1896.

[33] Proc. Iowa Acad. Sci. **3**: 106–135. 1895.

[34] Garden and Forest **10**: 14. 1897.

[35] BOT. GAZ. **21**: 275. 1896.

[36] Einfluss von Kontakt und Zug auf rankende Blattstiele. Inaugural-Diss., 36 pp. 2 col. lith. plates. No date. Leipzig.

The morphologically upper side of the petioles of Solanum, Lophospermum, and Tropæolum, and the lower side of Clematis showed the greatest degree of irritability.

In his comparisons the author assumes a latent period of fifteen to thirty minutes for tendrils, which in reality react in ten to fifteen seconds.

The limited transmission of impulses in tendrils is duplicated in petioles. Curvatures, according to the author's measurements, are due to an accelerated growth of the convex side. The portion of the petiole in contact with a support undergoes great increase in thickness, and if the mechanical system is in the form of a crescent or open ring, it is closed.

Stretching tension exerts an influence upon twining petioles similar to that of typical organs. Stretching tension acting upon the encircling part of the petiole in some instances induced in some species an exaggeration of the contact effect, and in others a diminution.

This paper has but recently reached the hands of the reviewer, and bears no date of imprint. Reference is made to a work published in 1892, and the reader has no means of determining the time of publication within five years.—D. T. MacDougal.

NEWS.

DR. KIENITZ-GERLOFF has been called to a professorship in Weilburg.

PROFESSOR F. A. HAZSLINSZKY, one of the well known Hungarian mycologists, died at Eperies, Hungary, on the 19th of November last.

A BIOGRAPHICAL SKETCH of the late Henry Trimen, with portrait, appears in the *Journal of Botany* for December (1896), prepared by the editor, Mr. James Britten.

A SECOND ISSUE of Bailey's *Survival of the unlike* is about ready. A few minor alterations have been made and a fuller statement given to the concluding paragraph of the first essay.

THE TITLE of "professor" has been conferred upon Dr. Karl Müller, of Halle, the editor of *Natur*, and better known to American readers as the author of the *Synopsis Muscorum*, and many other works and papers on bryology.

A GARDEN SCHOLARSHIP is to be awarded by the Director of the Missouri Botanical Garden, Dr. Wm. Trelease, before April first. Applications must be in before March first, and the preliminary examination will be held at St. Louis March 9.

A REVISED EDITION of Wright's "Guide to the organic drugs of the U. S. Pharmacopœia of 1890" has been issued by Eli Lilly & Co. of Indianapolis. It contains much additional material, and is of interest not merely to pharmacists, but also to botanists who are interested in the medicinal properties of plants. It may be had from the firm for a two-cent stamp, or, bound in leather, for twenty-five cents.

A VERY INTERESTING ACCOUNT of cryptogamic botany in Harvard University, from 1874 to 1896, has been prepared by Dr. W. G. Farlow. The account concludes with a list of contributions from the cryptogamic laboratory, containing thirty-seven numbers, to which are added eight unnumbered papers which contain the results of work done by their authors while studying in the laboratory, besides the numerous papers by Professor Farlow himself.

MRS. GRAY has completed the mounting of the autograph letters of various botanists which Dr. Asa Gray preserved from his voluminous correspondence, numbering more than eleven hundred. With the letters, whenever possible, an engraving or photograph of the writer has been mounted. Some of the autographs are extremely rare, and the painstaking care which Mrs. Gray has bestowed upon preparing and mounting the letters, has increased the value of the collection many fold.

IN PROSECUTING the work of "Experiment Station Extension" under the Nixon law in the State of New York, Professor Bailey has conceived and is publishing a series of leaflets for use in the rural schools. These leaflets are intended to be put into the hands of teachers, or even of pupils, as suggestions for object lessons about common things. Number 1 is dated December 1, 1896, and is entitled "How a squash plant gets out of the seed," and is illustrated by fourteen admirable outline drawings. The idea is a good one.

HEINRICH BEHRENS suggests a new method of preserving juicy fruits, fleshy parts of plants, fungi, etc.[1] The parts are dipped when the surface is air-dry into a warm 5 per cent. solution of gelatine. If the gelatine does not adhere, the object is first dipped in 70 per cent. alcohol and then immediately into the gelatine. After cooling the object is dipped into a mixture of twenty parts of formalin (40 per cent. formaldehyde) and fifty parts water. An insoluble layer of gelatine is thus formed, destroying all adherent putrefactive and fermentative germs, and preserving the watery parts in their natural form and color.

MR. AUGUSTINE HENRY, of Mengtse, China, has just published[2] an interesting account of Chinese "soap trees." The fruits of these trees are in common use among the Chinese for washing purposes, in spite of the importation of alkaline soaps. Little is known concerning the chemical nature of the fruits which give them such useful properties, but it is assumed that they contain saponin. Mr. Henry finds that the soap trees belong to the Sapindaceæ and Leguminosae, and that all the genera are represented in America excepting Pancovia. The list of trees whose fruits are so used throughout China contains twelve species, eight of which are species of Gleditschia, and the others species of Sapindus, Pancovia, Gymnocladus, and Acacia.

UNDER A new law, announcement is made by the United States Department of Agriculture that the serial, scientific, and technical publications of the department are not for general distribution. All copies not required for official use are turned over to the Superintendent of Documents, who is empowered to sell them at cost. All applications for such publications should therefore be made to the Superintendent of Documents, Union Building, Washington, D. C. He is not, however, allowed to sell more than one copy of any public document to the same person, and remittance should always be made to him and not to the Department of Agriculture. Do not send checks or stamps.

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[1] Zeits. f. angewandte Mikroskopie **2**:36. 1896. Cf. Bot. Centralbl. **68**:286. 1896.

[2] Amer. Druggist and Pharm. Record, **29**:317. 1896.

THE PUBLISHER of Engler & Prantl's *Natürlichen Pflanzenfamilien* (Wilhelm Engelmann, Leipzig) announces that parts II, III, and IV, treating the phanerogams, are complete with the exception of the conclusion of Labiatæ, Umbelliferæ, and Cornaceæ, and the supplements including genera added during 1896 to the families already published. Harm's Cornaceæ is in press; Briquet promised to complete the Labiatæ by the close of 1896, as did also Drude the Umbelliferæ. Engler is preparing the supplementary parts. The prospect is therefore that the phanerogams will be completed during the first half of 1897. In order to enable subscribers to use these parts conveniently at once a separate index for phanerogams and cryptogams will be issued. A capable bibliographer is already at work on the index. This course, although objectionable, has been determined upon because of the necessarily slow progress of the cryptogamic parts. The preparation of the algæ and fungi progresses rapidly and will probably be finished by the close of this year, but it is doubtful whether the bryophytes and pteridophytes can be ready before 1898.

THE COLLECTING SEASON of the Mexican Botanical Club for 1897 will open March 1. The territory they propose to explore will embrace the states of Guerrero, as far south as Acapulco, Michoacan, Jalisco, Colima, and Territory of Tepic, probably as far north as San Blas. This is a most picturesque and fertile country, ranging from sea level to 14,000 feet elevation, interspersed with numerous valleys, deep cañons, rugged mountains, active volcanoes, and abundant streams of water. Under their careful system of explorations they should reap a rich harvest of economic plants, and new varieties valuable for cultivation and investigation. As a result of their operations, we look for new and rare varieties of orchids, palms, ferns, etc., which they propose to mail weekly to members directly from the field in growing condition. They will also be well equipped with cameras for photographing scenery, and especially plants, unmounted copies of which will be given to each member. The work will be again under the direct management of Mr. Wm. Brockway, Maravatio, Mexico. We understand that the club is desirous of securing a few more members at once, and full information may be obtained by addressing him or Professor L. N. Bailey, Ithaca, N. Y.

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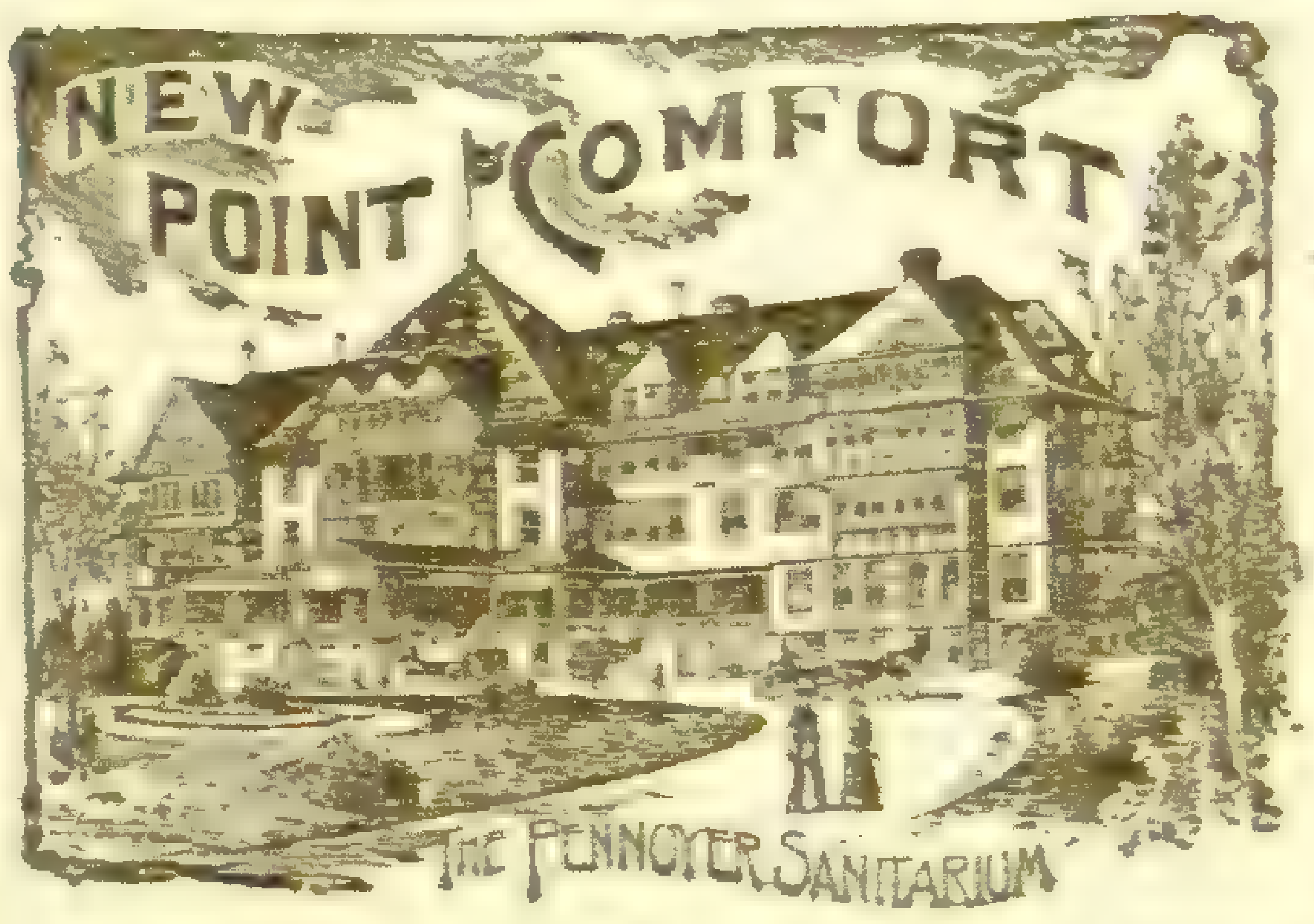

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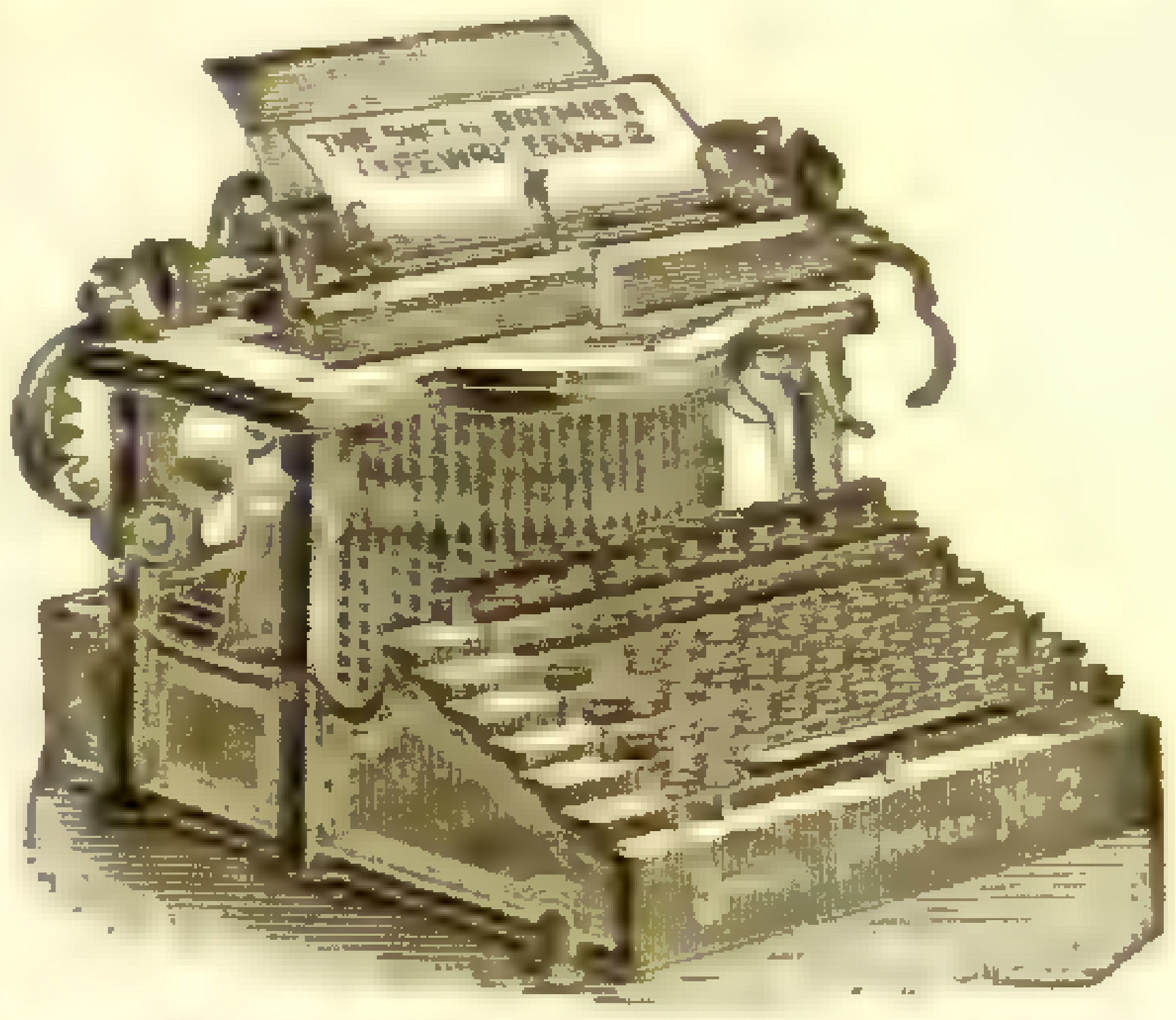
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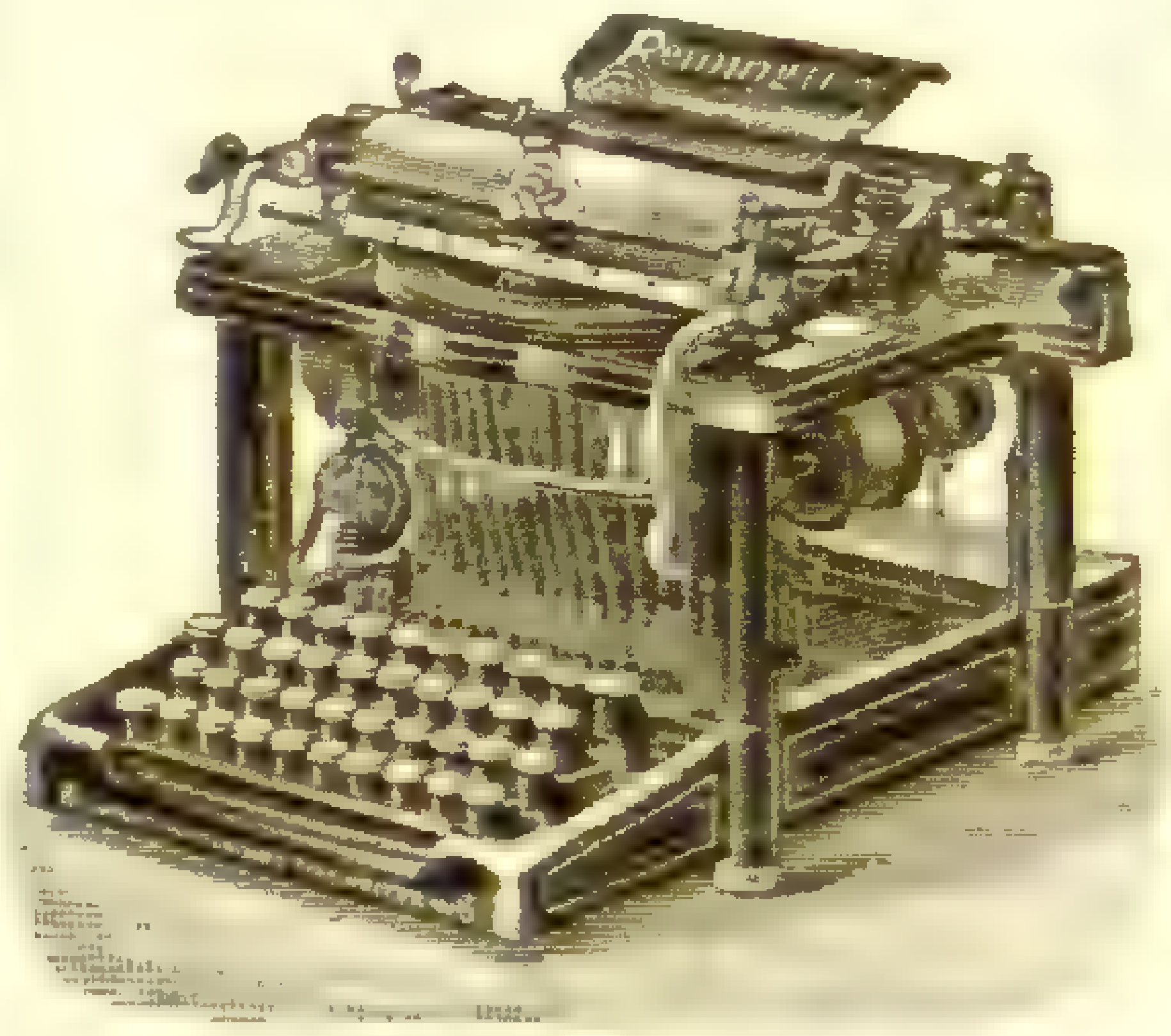

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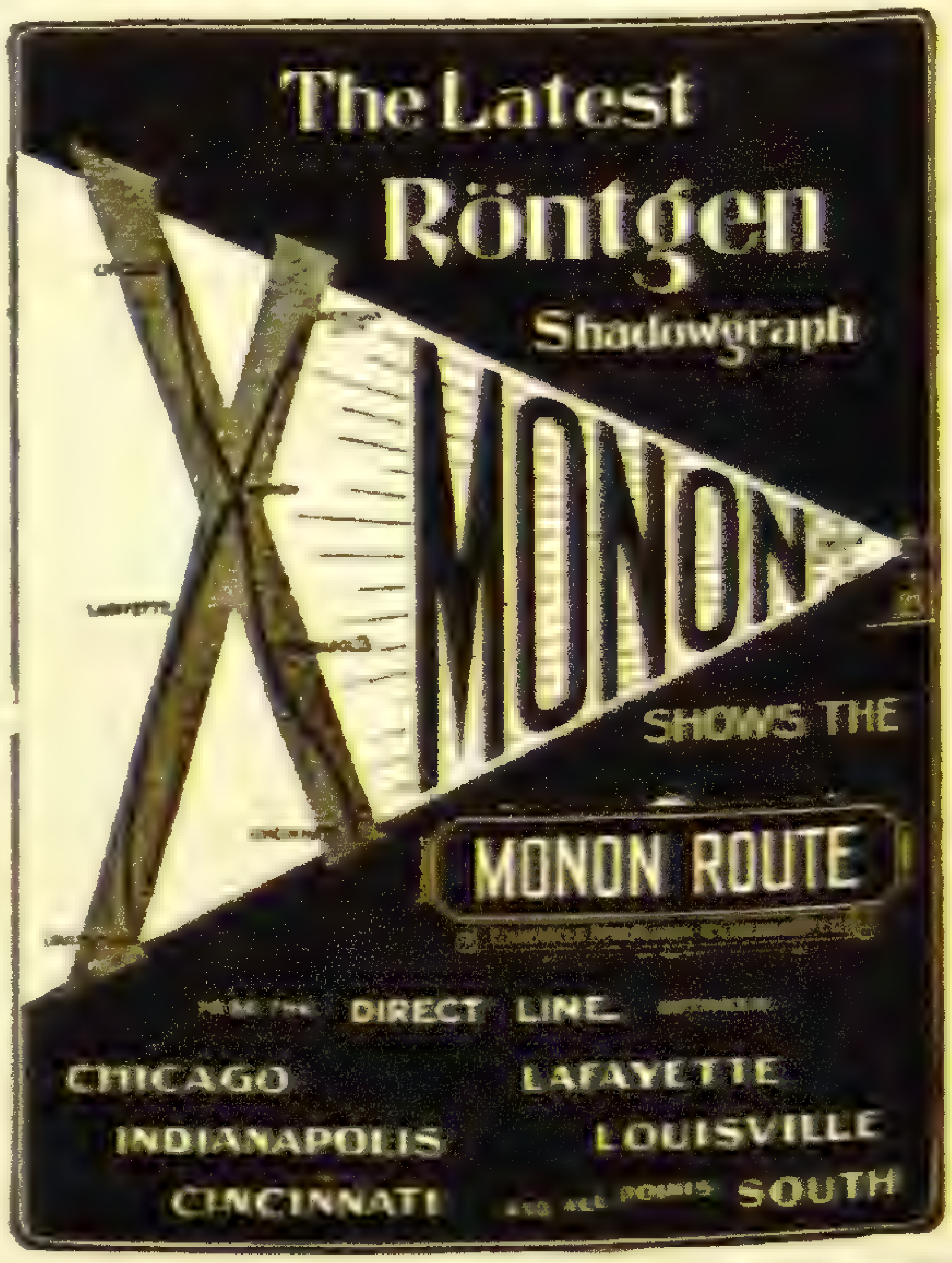
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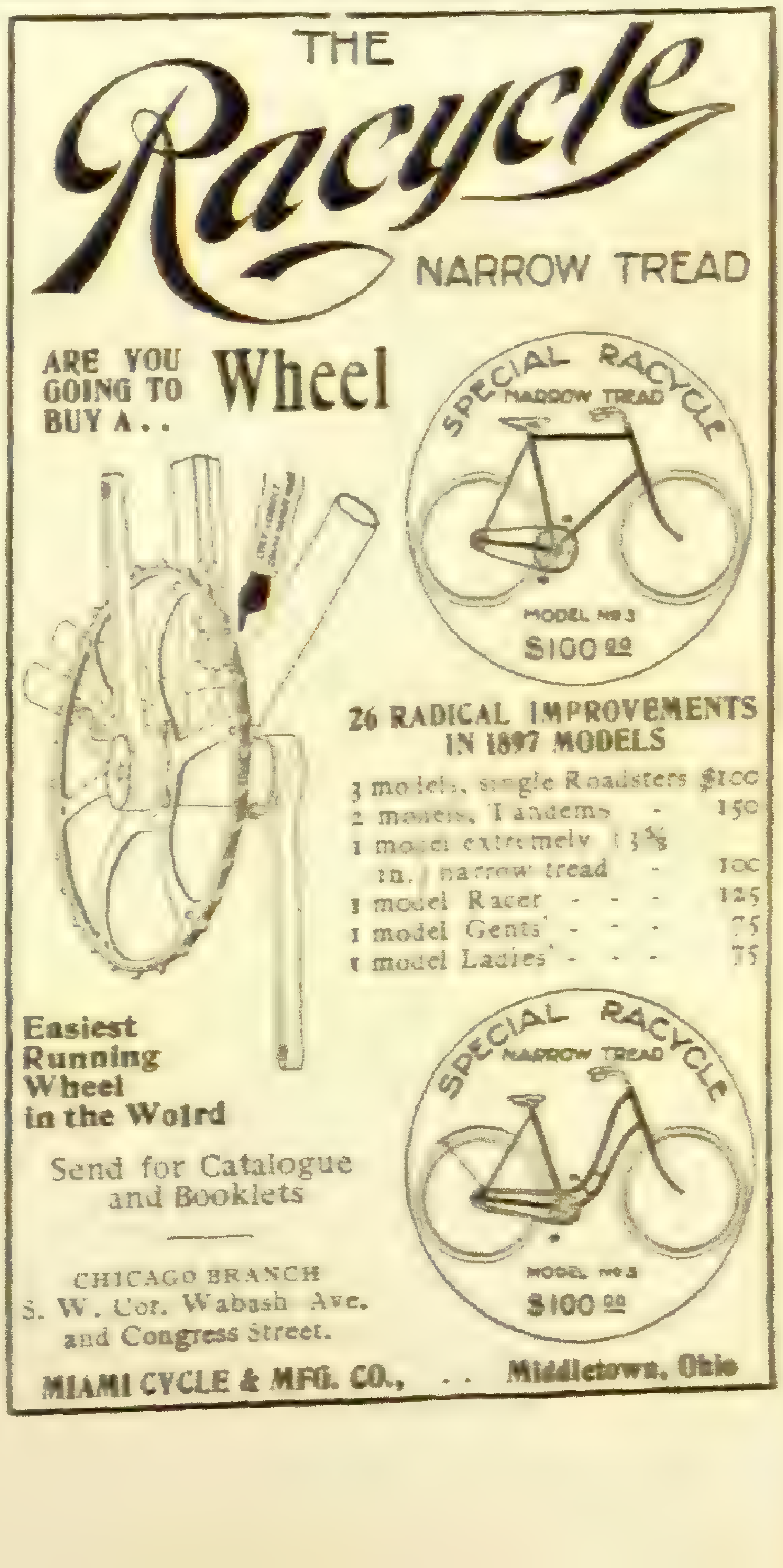

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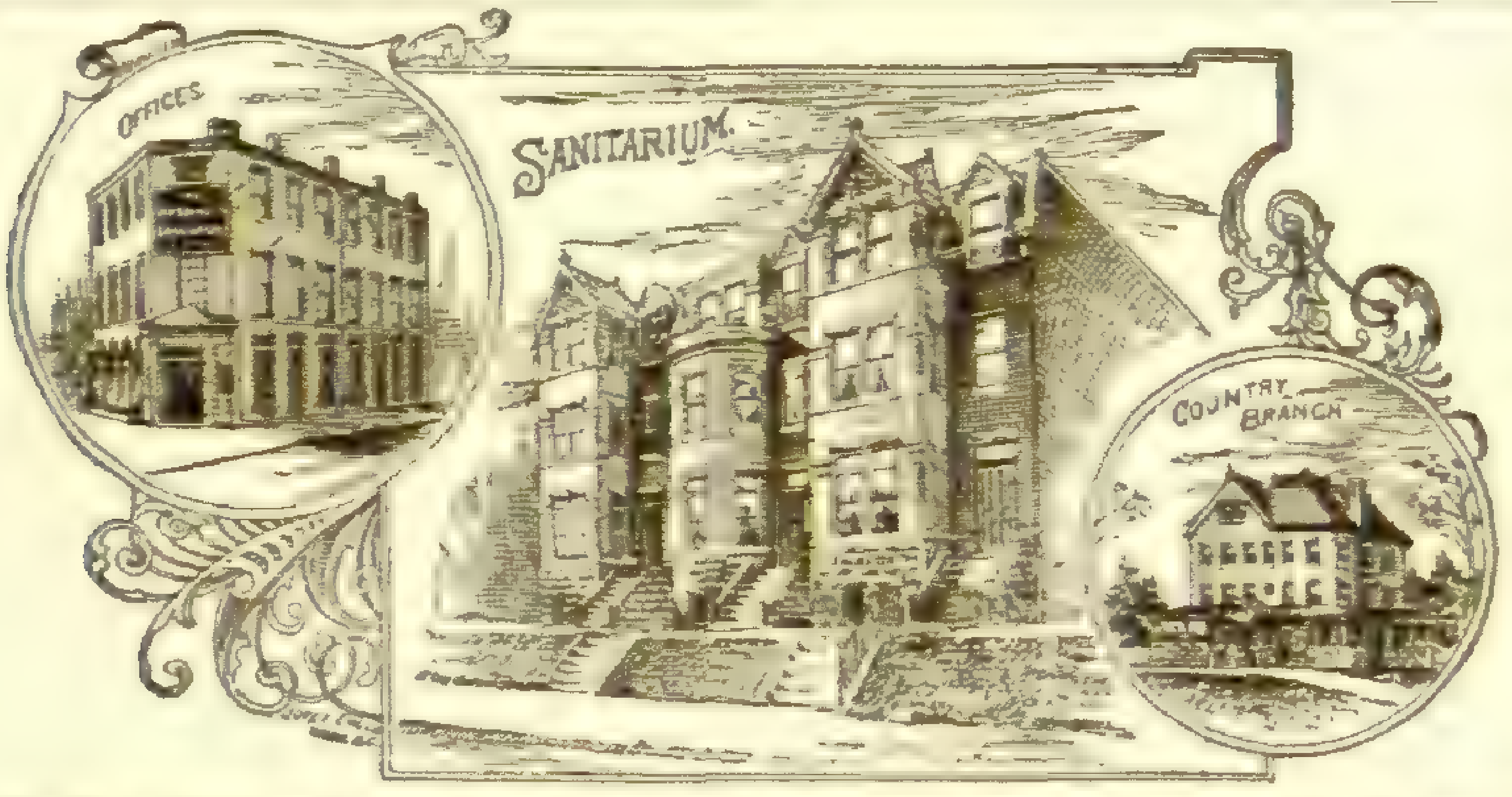

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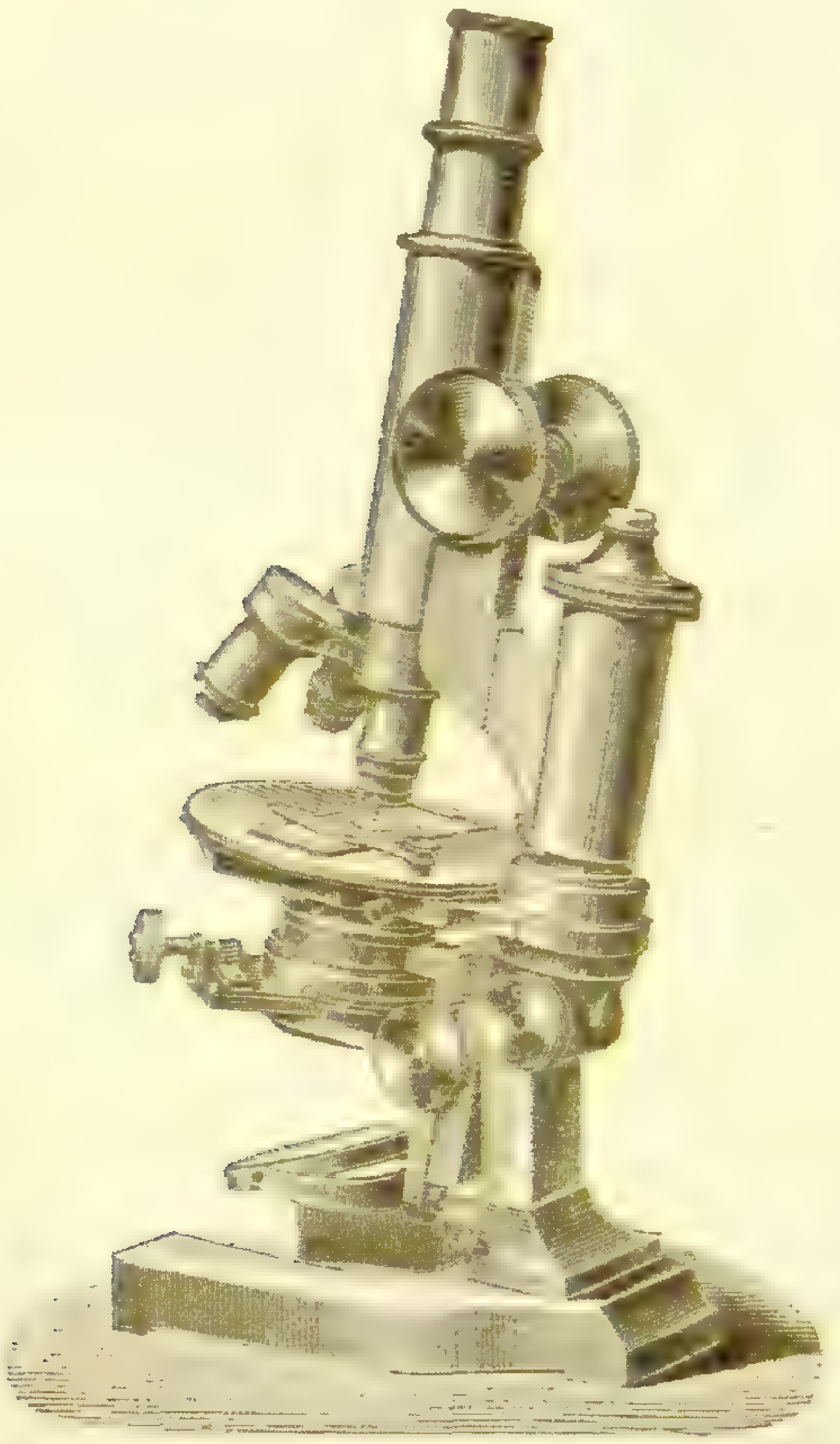

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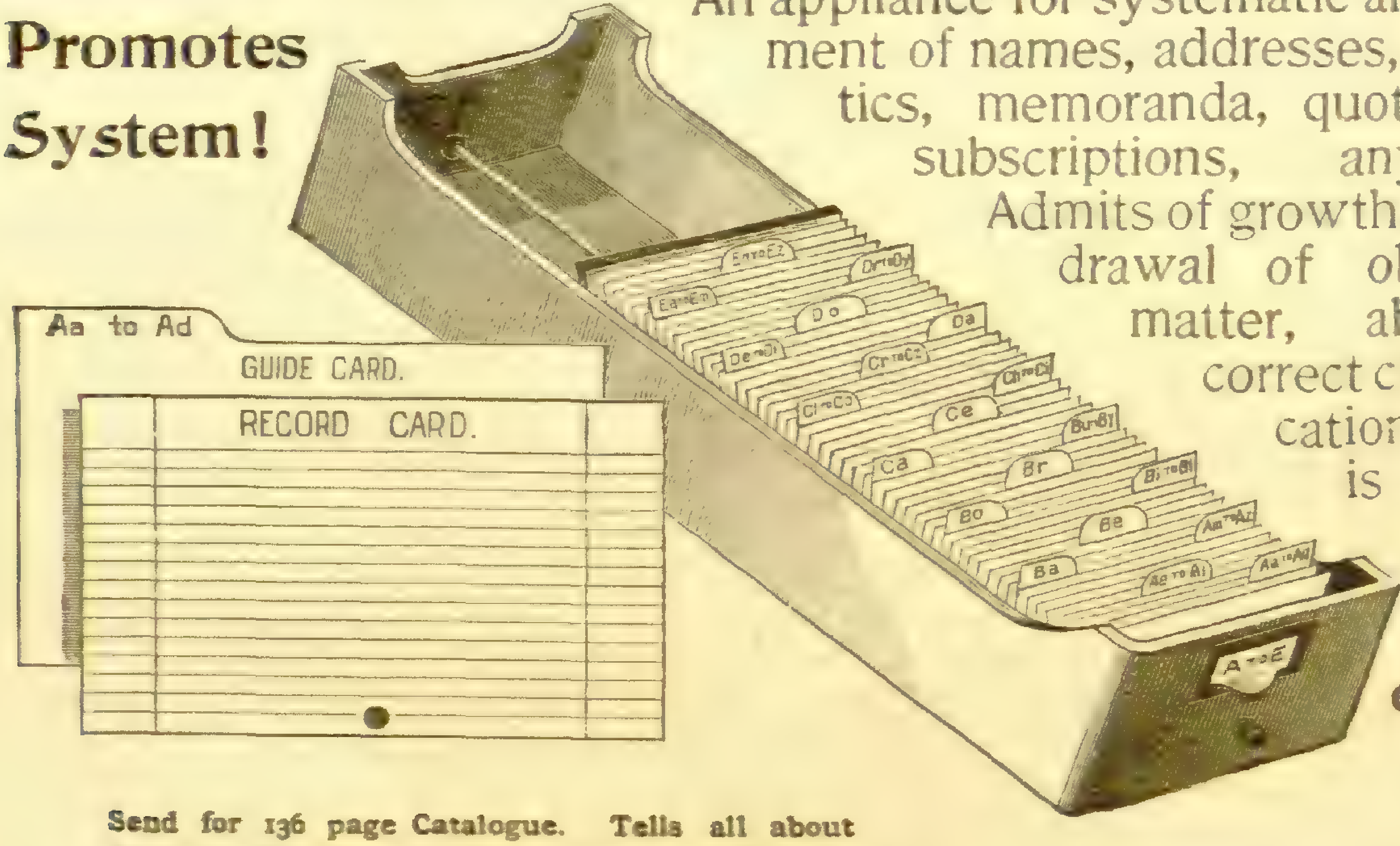
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VOLUME XXIII NUMBER 3

BOTANICAL GAZETTE

MARCH 1897

CONTRIBUTION TO THE LIFE HISTORY OF SALIX.[1]

CHARLES J. CHAMBERLAIN.

(WITH PLATES XII–XVIII)

MANY considerations combine to make the embryology of Salix an inviting subject. Taxonomists at present place it so near the most primitive dicotyls that it becomes interesting from a phylogenetic standpoint. Treub's researches upon Casuarina (22) have yielded some remarkable results. He finds that it has a great number of macrospores, but no synergids and no antipodals; that there is no primary endosperm nucleus formed by the fusion of polar nuclei, but an endosperm formed before fertilization; that cell walls are formed about the oosphere and its accompanying cells before fertilization; and finally that the pollen tube enters by way of the chalaza instead of the micropyle. Treub considered these results so significant that he proposed a primary division of angiosperms into chalazogams and porogams, Casuarina being the sole representative of the former. The researches of Nawaschin (25) and Miss Benson (26) have disproved the taxonomic value of chalazogamy, but the unique structures of the Casuarina embryo sac have not been discovered as yet in any other plant.

With such discoveries among the lower dicotyls, Salix might be expected to prove instructive. The perplexing variation in species, the well known propensity to hybridize, and the frequency of sports increase the probability of interesting results. Finally, Chicago and its environs afford an abundance of material representing three-fourths of the species credited to the United States.

---

[1] Contributions from the Hull Botanical Laboratory. III.—The previous Contributions are, I. "The embryo sac of Aster Novæ-Angliæ," by Chas. J. Chamberlain. BOT. GAZETTE **20**: 205–212. *pl. 15, 16.* 1895; II. "Notes on the fertilization and embryogeny of Conifers," by John M. Coulter. BOT. GAZETTE **23**: 40–43. *pl. 6.* 1897.

At first it was my purpose to examine Salix only with reference to chalazogamy and the structures of the embryo sac, but as the subject developed it was thought best to extend the scope of the work. The subjects discussed are (1) material and methods, (2) organogeny of the flower, (3) development of the microspores, (4) origin of the macrospore, (5) germination of the macrospore, (6) pollen tubes and fertilization, (7) development of the embryo, (8) teratology, (9) Salix and other Amentiferæ, (10) summary.

Complete series from the formation of the archesporium to the mature embryo were studied in *S. petiolaris* and *S. glaucophylla*. Series lacking but few stages were studied in *S. tristis*, *S. discolor* and *S. cordata*. Less complete series were studied in twelve other species.

The investigations were conducted under the guidance of Professor John M. Coulter, whose valuable suggestions and kindly encouragement are acknowledged with gratitude.

MATERIAL AND METHODS.

The greater part of my material was collected at Grand Crossing, Illinois, but many gatherings were made from the higher ground north of Chicago, and from the sand dune region of northern Indiana. The collecting began February 14, 1895, and gatherings were made at intervals of two or three days until the latter part of May. A few collections of buds were made in the autumn and winter. This furnished nearly complete series in *S. glaucophylla*, *S. cordata*, and *S. tristis*, with many other species represented by several stages. During the following spring gaps in the series were filled, a good series of *S. petiolaris* was collected, and many monstrous forms were found. In August and

December collections were made to determine the histological character of the winter buds.

At first 1 per cent. chromic acid was used for killing and fixing, but experience proved that better results could be obtained by adding a little acetic acid to counteract the tendency to shrink. The material was left in the fixing agent 12 to 24 hours, then washed in water for 24 to 36 hours, and after passing through successive grades of alcohol was left in 70 per cent. alcohol until needed for use. Flemming's fluid proved excellent, and the same must be said of Merkel's and Hermann's, but these are rather expensive. Picric acid with a trace of acetic is also to be recommended. To insure rapid fixing the tops of many of the pistils were cut off down to the level of the ovules.

Xylol proved the best clearing agent. The transfer from absolute alcohol to xylol was made gradually by adding small quantities of xylol to the alcohol until the mixture contained about three parts of xylol. The mixture was then poured off, and pure xylol was substituted. As soon as the material was cleared, a lump of paraffin was added, and thus the transfer from xylol to paraffin was made gradual. One to three hours in the bath is sufficient after such treatment.

Serial sections were cut with a Thoma microtome. Mayer's albumen fixative in connection with the water method was used for fixing the sections to the slide. Cyanin and erythrosin was the best combination for embryo sacs. Delafield's hæmatoxylin was good for embryos and the early stages of anthers. Safranin and gentian violet, cleared in clove oil, seems to be the best combination for the pollen grain.

The celloidin method was tested, but did not give as good results as paraffin, and besides was unnecessarily tedious.

All drawings were made with an Abbé camera lucida. A $\frac{1}{12}$ Bausch and Lomb immersion was used for all the drawings except those of *pl. XVIII* and *fig. 66a*.

ORGANOGENY OF THE FLOWER.

No attempt was made to secure a perfect series of stages in the development of the floral organs. Several species were collected in August to determine the condition of the buds. In some of these the carpels appeared as slight protuberances; others were more advanced and showed the carpels outlined but with no trace of ovules. In October buds of *S. cordata* and *S. glaucophylla* the nucellus of the ovule was quite conspicuous, but the integument had not begun to form. As a rule, the integument does not form until spring. Early February buds from a small plant of *S. cordata* showed carpels but no trace of ovules. Material from the same plant taken three weeks later showed a conspicuous integument. Staminate buds, collected in October, showed the stamens fairly outlined. The gland, or nectary, is frequently conspicuous in the winter buds.

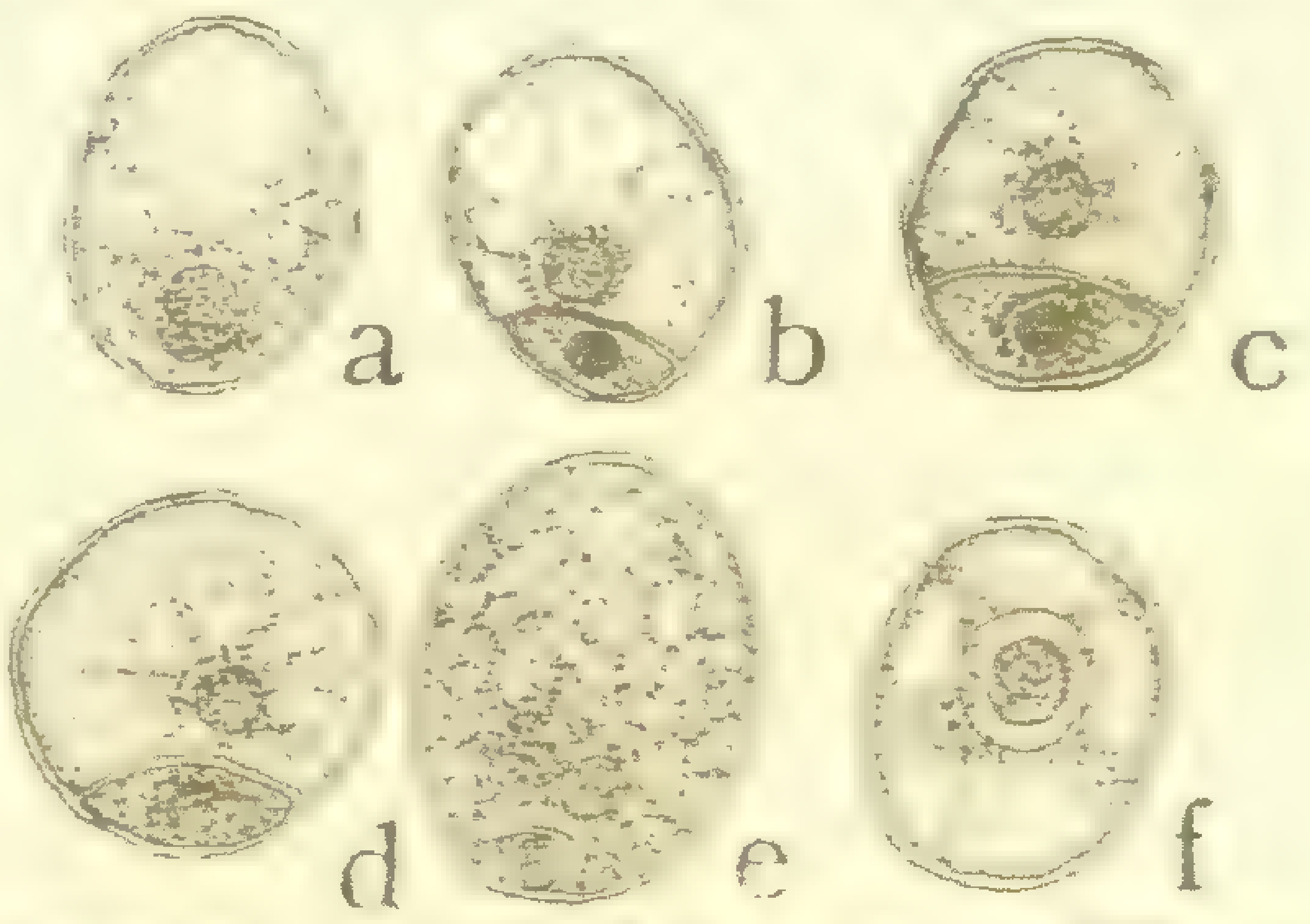
A diligent search was made for rudiments of floral organs which might be expected to be found were the flowers of Salix reduced rather than primitive, but an examination of early stages in several species failed to show the least trace of anything which could be interpreted as a petal or sepal, or as indicating an earlier ambisporangiate condition. The prominent nectar gland has a single terminal pore. There is nothing in its history which would allow it to be regarded as a reduced or transformed floral organ.

DEVELOPMENT OF THE MICROSPORES.

Staminate buds of *S. glaucophylla*, collected early in October, showed the condition represented in *fig. 1*. There are here three layers of cells between the epidermis and the sporogenous cells. The three layers appear alike, the endothecium and tapetum having no distinguishing characters. In some cases there were four layers instead of three. Another specimen of *S. glaucophylla*, collected at the same time, had the tapetum somewhat differentiated. That buds pass the winter in about this state is proved by the fact that buds of the same species collected in midwinter showed the same condition. Material of *S. tristis*, collected late in March, showed the tapetum well differentiated, but the endothecium still appearing like the middle layers (*fig. 2*). The number of middle layers may vary from one to four, even in the same anther. In *S. glaucophylla* and *S. tristis* the number of these intervening layers is usually two. Some anthers of *S. cordata* with the pollen grains nearly mature showed no layer at all between the endothecium and the tapetum (*fig. 8*). The cells of the mature tapetum often have two nuclei. The strengthening of the endothecium does not commence until the tapetum has begun to disorganize. All of the layers between the endothecium and the spores disintegrate, and the spores float in a granular fluid (*fig. 9*).

The sporogenous cells, as shown in *figs. 1* and *2*, are the mother cells of the microspores. This is proved by the fact that the number of sporogenous cells in a transverse section of an autumn or winter microsporangium is approximately the same as the number found in spring microsporangia whose sporogenous cells are beginning to show by their spherical form that they are undoubted mother cells. The large size of the nuclei also favors this interpretation. An examination of several species indicates that most staminate buds pass the winter in the spore mother cell stage. In buds of *S. tristis*, collected late in March, the spore mother cells had not yet assumed the spherical form. *S. cordata* and *S. glaucophylla*, collected at the same time, had already passed the tetrad stage.

The nucleus of the microspore divides some time before the spores are shed. The division of the nucleus is not followed by the formation of a cell wall. In *Populus monilifera*, representing the other genus of the Salicaceæ, a wall is formed separating a smaller lenticular cell from the larger one. In Salix the generative nucleus soon organizes a part of the surrounding cytoplasm and becomes a fusiform cell. Since spores already upon the stigmas showed no further differentia-



Pollen grains of *Populus monilifera*: *a* and *f*, before division of the nucleus; *b*, *c*, *d*, lenticular cell cut off from the rest of the spore; *e*, division of the nucleus of the larger cell. × 072.

tion, the division of the generative cell, which presumably takes place, although I was not so fortunate as to observe it, must occur after the pollen tube begins to form.

ORIGIN OF THE MACROSPORE.

The macrospore invariably has its origin in a hypodermal cell at or near the apex of the nucellus (*fig. 10*). Sometimes there are two or three hypodermal cells which by their size and intense staining indicate their sporogenous nature (*fig. 11*). A few cases were found in which two macrospores had developed to the fertilization stage, so it is evident that more than one of the sporogenous cells may continue its development. The usual appearance of an ovule before the differentiation of the archesporium is shown in *fig. 12*. In the nucellus six hypodermal cells, three of which are represented in the drawing, might be called archesporial cells, but I have not applied this term to a cell until it shows by its denser contents and reaction to stains that it has the characteristics of an archesporial cell.

The archesporial cell divides into a primary tapetal cell and a sporogenous cell which is the mother cell[2] of the macrospore (*fig. 13*). The primary tapetal cell sometimes gives rise to a tier of five or six cells, resulting in a deep placing of the macrospore. Usually there is a tier of two or three cells; but occasionally the primary tapetal cell does not divide (*figs. 14–19*). All of these variations were found in *Salix glaucophylla*, and an examination of several other species indicated a similar lack of uniformity.

The further development of the macrospore mother cell presents more important variations. Almost always it divides into two cells, a smaller one nearer the micropyle, and the larger one which becomes the fertile macrospore. The smaller cell either undergoes one transverse division, thus giving rise to two potential macrospores, or it does not divide at all (*figs. 14* and *17*). In a case like *fig. 17* there is a possibility that the two smaller cells may have been cut off in succession from the larger cell, but as no mitotic figures were found in this stage this question could not be settled.

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[2] To avoid confusion this primary sporogenous cell will be called the *macrospore mother cell*. It is the cell in which the reduction of chromosomes takes place. If no tapetal cell is cut off, as in Lilium, Tulipa, and Fritillaria, the hypodermal archesporial cell becomes the macrospore mother cell without further division. If the macrospore mother cell divides into four, as in Polygonum, each of these is called a *potential macrospore*. If the macrospore mother cell gives rise to three cells or only two, each of these is a potential macrospore. In all cases the potential macrospore which matures is called a *fertile macrospore*.

Sometimes the macrospore mother cell does not divide but develops directly into the macrospore (*fig. 23*). If any potential macrospores have been cut off, they are crowded and absorbed by the growing fertile macrospore until nothing remains of them but a refractive cap, and even this soon disappears. These variations are noteworthy. In Gamopetalæ it is said (21) to be the rule that the macrospore mother cell becomes the macrospore directly; in monocotyls and in the Archichlamydeæ among dicotyls the macrospore mother cell gives rise to four potential macrospores, one of which becomes the fertile macrospore. In some plants there are three potential macrospores; in others there are two; in still others the macrospore mother cell becomes the fertile macrospore without any division. Standard texts, as well as the original papers from which their information is obtained, leave the impression that for a given species there is little or no variation in the mode of origin of the macrospore, and I must confess that as far as the number of potential macrospores is concerned, I have noted the same uniformity in my study of Compositæ. But serial sections of about three hundred ovules of *S. glaucophylla* showed all of the above mentioned variations. *S. discolor* and other species indicated a similar variation. It is possible that generalizations have been based sometimes upon a few sections, and even these taken from the same plant. Such results are likely to be very uncertain, since individual plants often present variations from year to year. Not a single instance was found in which the fertile macrospore developed from the potential macrospore nearer the micropyle, as sometimes happens in Aster (28). The only suggestion of such an occurrence is shown in *fig. 21*, and even here the usual cell has two nuclei. This preparation looks as if two potential macrospores might be developing one above the other.

GERMINATION OF THE MACROSPORE.

A typical nucellus just before the division of the primary nucleus of the fertile macrospore is represented in *fig. 14*. There is a tier of three tapetal cells and one potential macrospore, the latter already somewhat crowded by the growing fertile macrospore. The nucleus of the fertile macrospore is accompanied by the structures known as centrosomes. No attempt was made to investigate these bodies, but they were noticed in two other preparations. In *fig. 17*, which shows a portion of a nucellus, there is a tier of four tapetal cells and two potential macrospores. The first division of the primary nucleus of the fertile macrospore was observed in about forty cases. The most frequent appearance is that shown in *fig. 19*, which has a central strand of protoplasm traversing a vacuole and connecting the daughter nuclei. The vacuole may be absent, as in *fig. 18*. The spindle in the first division of the primary nucleus is parallel with the long axis of the macrospore, the only exception observed being that shown in *fig. 21*. In the second division several mitotic figures were found. The spindles at the micropylar end were always transverse to the long axis of the macrospore, while those of the antipodal end were always longitudinal. *Fig. 20* might fairly represent all the cases examined. In *fig. 16* the nuclei have a slightly different position, but it must be remembered that the nuclei in a germinating macrospore gradually change their position. A peculiar four-celled stage is shown in *fig. 22*, where the position of the nuclei and the size of the nucleus at the micropylar end would seem to indicate that after the first division the micropylar nucleus had failed to divide, while the nucleus at the antipodal end had divided and one of the resulting nuclei had divided again. The next division, giving four nuclei at each end of the sac, was observed in only two instances, neither of which was very satisfactory. One of these (*fig. 23*) indicates that the longitudinal arrangement of spindles in the antipodal end and the transverse arrangement in the micropylar is continued in this stage. A portion of the contents, probably a micropylar spindle, has been washed out from this section, for the clear space between the mitotic figures is not a vacuole. It is common enough to find the eight-celled stage just as the two polar nuclei are fusing to form the primary endosperm nucleus. It would seem that after the second division the development proceeds rapidly, otherwise in examining a large number of sections from material representing stages from the first division of the primary nucleus to the eight-celled stage one should find the eight-celled stage as frequently as any other. As a matter of fact, the uninucleate condition is found most frequently; macrospores with two nuclei are not so frequent; those with four nuclei are comparatively rare; and those with eight nuclei are very exceptional. These observations show that the macrospore remains for some time in the uninucleate condition, a fact further indicated by the differences in the degree of maturity of ovules containing such macrospores. The increasing infrequency of the succeeding stages indicates that after germination has begun, development proceeds with increasing rapidity until the gametophyte has reached its fertilization period.

The macrospore may reach the eight-celled stage without increasing very much in size, or during the divisions which result in the four-celled and eight-celled stages there may be considerable enlargement at the expense of surrounding cells (compare *fig. 16* with *fig. 24*). After the eight-celled stage is reached, the macrospore increases greatly in size, as may be seen by comparing the figures of *pl. XIII* with those of *pl. XII*, all of which are drawn to the same scale. This macrospore was a puzzle to me for more than a year. I had not yet found the third division resulting in the eight-celled stage, but the egg apparatus and primary endosperm nucleus seemed to demand such a stage. I could find no antipodals, and Treub's Casuarina (22) without antipodals added to the perplexity. An effort to connect such stages as *fig. 16* and *fig. 28*, so as to account for a macrospore without antipodals, was unsatisfactory on account of the numerous instances in which nuclei were fusing to form the primary endosperm nucleus. A prolonged search revealed the missing antipodal cells (*figs. 26, 27*). A careful examination of about five hundred macrospores yielded six with indisputable antipodals and, since they are known to exist, other preparations show what may be reasonably interpreted as their disorganized remains. The antipodals are small, three in number, and are situated at the extreme chalazal end of the macrospore. In *fig. 31* the three cells marked *a* may be antipodals, for there does not appear to be any trace of a pollen tube or other evidence of fertilization, and the nucleus marked *e* looks like the primary endosperm nucleus rather than an endosperm nucleus resulting from its division. A somewhat similar condition is shown in *fig. 33*, but in this case there is a pollen tube already within the macrospore. If in either or both of these cases the cells marked *a* are cells of the endosperm, the primary endosperm nucleus has divided very early, and the appearance of the cells is unusual. It may be possible that the group of three cells has arisen from the division of the lower polar nucleus without any fusion with the upper one having taken place. If the nuclei belong to the endosperm, these two cases are the only ones observed in which there were more than two nuclei in the endosperm before the first division of the oospore.

In the the fusion of the polar nuclei to form the primary endosperm nucleus, details were not worked out, as Salix is not a favorable form. It may be noted merely that the fusion seems to be complete, even the nucleoli fusing to form one large nucleolus. A dense strand of protoplasm usually extends from the primary endosperm nucleus to the oosphere.

A few of the cells surrounding the chalazal end of the sac are very erythrophilous, probably through the influence of the antipodal cells.

It is very common to find the whole egg apparatus bursting through the apex of the nucellus into the micropyle. The pointed ends of the synergids and sometimes the entire egg apparatus are thrust through the wall of the macrospore (*figs. 28, 30, 39*, and others).

The oosphere is sometimes spherical, but more frequently elongated and tapering slightly toward the micropylar end, which almost invariably contains a large vacuole. The nucleus is at the opposite end in a dense mass of protoplasm. In rare cases the oosphere is scarcely organized into a definite shape (*fig. 25*).

The synergids have their nuclei, which sometimes divide (*fig. 27*), and most of their protoplasm in the micropylar half, while the other half of the cell is almost entirely occupied by a large vacuole. The tips of the synergids frequently become covered by a strong wall which persists long after all other traces of the synergids have disappeared. These caps display considerable variation. There may be only a faint trace of striæ (*fig. 30*), or the striæ may be more prominent (*fig. 27*). Frequently the caps are so strongly developed that they give the synergids a decidedly beaked appearance (*figs. 28, 29, 36* and *39*), the beaks being cyanophilous, thus contrasting sharply with the prevailing erythrophilous structures of the macrospore.

Schacht (2) described such caps or "filiform apparatus" in *Santalum album*, but misinterpreted their relation to the synergids. Strasburger (18) some time afterward examined Santalum and mistook the cap for the entire synergid and the lower part of the synergid for an oosphere, thus getting a macrospore with two oospheres. He afterwards discovered his mistake and gave an excellent description of Santalum. Strasburger says that the caps contain minute pores through which there oozes an albuminoid substance which may attract the pollen tube. My preparations (*figs. 36* and *39*) support this view. In every instance in which beaks and pollen tubes were found, the pollen tube entered between the beaks. The beaks undoubtedly serve to enlarge the micropyle, thus facilitating the entrance of the tube. As a rule, the farther the egg apparatus is thrust beyond the nucellus the more strongly are the beaks developed. The function of the beaks is probably to place the oosphere in a more favorable position and to attract and guide the pollen tube.

In the relative size of the nuclei and nucleoli of the primary endosperm nucleus, oosphere nucleus, and nuclei of the synergids the same uniformity was observed which characterized these structures in Aster. Over two hundred measurements in *Salix glaucophylla* gave the following results. The average length of the primary endosperm nucleus is 11.2 μ, and its breadth 10 μ; the diameter of the nucleolus being 5.7 μ. The oosphere nucleus is 8.8 μ long and 7.8 μ wide; and the diameter of its nucleolus 4 μ. The nuclei of the synergids are usually spherical, with an average diameter of 6.3 μ; and the diameter of their nucleoli 2.3 μ. All measurements were made from specimens which were ready for fertilization but had not yet been pollinated. The primary endosperm nucleus is always the largest, the oosphere nucleus next in size, and the synergid nuclei the smallest. The nucleoli have the same relative size. Measurements in other species gave the same relative results.

POLLEN TUBES AND FERTILIZATION.

In 1891 Treub (22) made the discovery that in Casuarina the pollen tube enters by way of the chalaza instead of the micropyle. In 1893 Betula was found to be chalazogamic, the discovery being made independently and almost simultaneously by Miss Benson (26) in England and Nawaschin (25) in Russia. Miss Benson at the same time added Alnus, Corylus, and Carpinus to the list, and Nawaschin soon added Juglans.

In consequence of these discoveries the pollen tubes of Salix were traced with considerable interest. In *S. glaucophylla*, *S. cordata*, *S. petiolaris*, and *S. tristis*, many pollen tubes were found, entering invariably by way of the micropyle. The chalazal region was examined critically in over three hundred ovules, but no trace of a pollen tube was found. The generative cell within the tube was observed but twice, and then under abnormal conditions (*fig. 38*). In a few cases the male cell was observed within the oosphere. The nearest approach to conjugation which my preparations afforded is shown in *fig. 40*. As the pollen tube enters the sac the synergids usually break down, and even their nuclei disappear. A sac immediately after fertilization is shown in *fig. 32*, in which the oospore is much enlarged and is forming a cellulose wall, and only a nearly disintegrated nucleus and a mass of protoplasm mark the remains of the synergids. The primary endosperm nucleus has not yet divided. A typical case is shown in *fig. 36*, which represents the pollen tube entering between the beaks of the synergids. The fusion of sex cells has probably not taken place, for no membrane has yet formed around the oosphere. The primary endosperm nucleus has increased greatly in size, but has not divided. The enlargement of the endosperm nucleus before fertilization is also shown in *fig. 34*. A somewhat later stage is given in *fig. 39*. The pollen tube can be seen still between the beaks of the synergids. The oospore has its cellulose wall, but the primary endosperm nucleus, although greatly enlarged as usual, has not yet divided, this enlargement beginning before the pollen tube reaches the beaks of the synergids.

A very peculiar case is represented in *fig. 38*, in which the embryo is quite advanced, but both synergids still persist. These synergids are plump and have definite cell walls, but have no vacuoles, and their nuclei are at the lower end instead of the upper where they are usually situated. The pollen tube, of course, is not the one which assisted in fertilization. A similar condition is shown in *fig. 35*, but here the synergids have no walls, and the pollen tube has collapsed. These cases indicate that fertilization may take place without the assistance of the synergids. Another singular case is furnished by *fig. 37*, in which the embryo is quite advanced, but the primary endosperm nucleus, although it has grown very large, has not yet divided.

As a rule, the division of the primary endosperm nucleus precedes the division of the oospore, and for a short time the nuclei of the endosperm multiply more rapidly than the cells of the embryo. A two-celled embryo is usually correlated with four nuclei in the endosperm, a four-celled embryo with eight or ten cells in the endosperm, but the endosperm does not continue to keep pace, and very soon the cells of the embryo outnumber the nuclei of the endosperm. The nuclei of the endosperm in Salix are never separated by cell walls.

DEVELOPMENT OF THE EMBRYO.

The first division of the oospore is always transverse to the longer axis of the embryo sac (*figs. 41, 42*). Occasionally this division separates the oospore into approximately equal parts, but it is more usual to find the suspensor cell larger and somewhat tapering, while its sister cell, which gives rise to the greater part of the embryo, is uniformly hemispherical. The suspensor cell divides transversely, and the daughter nuclei pass into the resting stage with full sized nucleoli before the embryo cell divides (*fig. 43*). The first division of the embryo cell is always longitudinal (*figs. 44-46*). The literature of the subject indicates that this division is almost universal in angiosperms, if we except those which have no suspensor and those in which the suspensor, though present, contributes nothing to the embryo. For instance, in Capsella after the first division of the oospore, the cell nearer the micropyle undergoes several divisions, forming the long suspensor, while its sister cell remains passive until the first longitudinal division occurs. This seems to be mere assumption, but it is quite probable that in dicotyls the terminal cell in which the first longitudinal division appears gives rise to the greater part of the embryo. Vines in his *Text-Book* has unfortunately figured the first division of the embryo cell in the type Capsella as transverse. The figures are diagrammatic "after Goebel and Hanstein" but Hanstein (3) figures the first division as vertical, and Goebel has followed him. Vines' text, however, without any particular reference to Capsella, states that the first division is usually longitudinal. Some of Hanstein's figures, like his *figs. 9* and *11*, which show a complete differentiation of the dermatogen before the first vertical division, certainly need to be verified, especially since the drawings were made from embryos squeezed out from the ovule and rendered transparent, a process which might cause one to lose a cell wall now and then. I have examined over twenty cases of the first division of the embryo in Capsella, and classes in the laboratory have thoroughly examined this and other early divisions in the same type, but have found no exception to the rule that the first division is longitudinal. Hanstein does figure the first division as transverse in Nicotiana and *Viola altaica*, but the figures are not convincing because the three nuclei in the large upper cell of his *figs. 7* and *9* of *pl. 5* make it possible to apply the usual interpretation.

In Salix, as a rule, the second division is also longitudinal and at right angles to the first, but it occasionally happens that the second division is transverse (*figs. 48, 51*). Both cases may be found in the same species, and in *S. cordata* and *S. petiolaris* I have found both on a single plant. In studying sections of embryos in these early stages, it is very easy to make mistakes. The young walls are often elusive, even in good preparations, and it is safest to make the sections thick enough to include the whole embryo. The nuclei will then enable one to interpret with certainty such stages as *figs. 48, 49, 53*.

The third division, usually transverse, but sometimes longitudinal, brings the embryo into the familiar octant stage (*figs. 53, 54*). The first transverse division separates the hypocotyl and cotyledon portions of the embryo.

After the octant stage one naturally looks for the periclines which mark off the dermatogen, and usually they are found, but the embryo sometimes proceeds a little further before this differentiation takes place. Sometimes a pericline cuts off the dermatogen in one octant, while a neighboring octant makes one or more divisions before the pericline appears (*figs. 56, 59*). In Capsella the first pericline usually appears in the upper octants; in Salix I can find no regularity, the first pericline appearing in one octant as frequently as in another. The entire dermatogen, exclusive of the suspensor contribution, may be cut off while the whole embryo consists of only sixteen cells. Very rarely, a part of the dermatogen is cut off while the embryo is still in the quadrant stage. An interesting stage is shown in *fig. 65*, which has, beside the dermatogen, sixteen cells which are to become differentiated into periblem and plerome. Some writers say that the periblem and plerome are differentiated very early, and they have even pointed out the first cell which is to produce plerome and the first which is to produce periblem, as if each cell were predestined to play a certain rôle. Hanstein's (3) classic account of Capsella, followed by the standard text-books, illustrates this idea; Fleischer (7) is equally definite in his description of Ornithogalum and Viola; and there is no doubt that their figures are accurate. Everyone who has cut Capsella knows how easy it is to duplicate most of Hanstein's figures. It is possible, perhaps probable, that the theory is correct in the case of Capsella, as it has a very regular embryo. In the other types which Hanstein considers, such an explanation is not so satisfactory. Fortunately, he does not attempt to apply the theory to all plants. Fleischer would apply it to dicotyls in general, but in his Asclepias one cannot distinguish periblem from plerome in early stages. It is evident that monocotyls, in many of which the plerome can hardly be called an independent system, must have a different explanation.

In the more regular embryos of Salix a person with some ingenuity might imagine this early differentiation into periblem and plerome, but the usual forms would demand some other theory. In Salix there are no four cells, which with their posterity are predestined to form the plerome of the plant, as in Hanstein's Capsella, but, as will be shown, the differentiation of these tissues occurs very late in the development of the embryo.

The relation between the suspensor and embryo in early stages is shown in *figs. 68, 70, 73*. It will be seen that the upper cell of the suspensor has divided by a longitudinal wall. A second longitudinal division, which may take place in embryos even younger than these, divides the upper cell of the suspensor into a plate of four cells (*fig. 53*). The dermatogen of the whole embryo, except the part contributed by the suspensor, is differentiated in embryos still younger than that shown in *fig. 65*. The dermatogen is the first of the primary tissues of the root tip to be differentiated, the first step in this differentiation being marked by the spindle in *fig. 77*. This division completes the dermatogen of the root tip, joining it with the dermatogen of the rest of the embryo, and furnishing the first layer of the root cap (*figs. 72, 75, 77a*). These figures show no differentiation into periblem and plerome. I do not believe that the suspensor contributes anything to the periblem in Salix. An embryo almost in the cotyledon stage (*fig. 74*) shows a complete dermatogen, but still no definite plerome and periblem. Nearly mature embryos (*fig. 66*) have the periblem and plerome sharply differentiated a short distance above the dermatogen of the root cap, but are indistinguishable at the apex, and both tissues still come from a common meristem. This figure represents the characters of the various regions of late embryos. The plerome cells are marked by dense protoplasmic contents free from vacuoles. Except very near the meristem they are elongated, and their long nuclei usually have two or more nucleoli. It is a region of cell elongation rather than of cell division. The periblem cells with their numerous vacuoles, spherical nuclei, and looser arrangement, present a noticeable contrast, which is emphasized by the fact that they are broader than long, and show evidences of cell multiplication rather than elongation. The prevailing divisions are transverse. The cells of the hypodermal layer of the periblem soon become sharply differentiated. The protoplasm with its nucleus is crowded against the inner wall of the cell by the encroaching vacuoles, which merge into one large vacuole containing a substance which seems to be suberin. A transverse section of the plerome and part of the periblem at this stage is represented in *fig. 69*. In *fig. 76* the periblem and plerome seem to be completely differentiated. At the apex there is only one layer of periblem between the plerome and dermatogen and this is usually the case in mature embryos. This figure also shows the usual appearance of the layers of the root cap. The root region of an embryo which has completed its intraseminal development has a separate meristem for the periblem and plerome (*fig. 67*, the plerome and dermatogen being shaded, and the initial cell of the plerome with one of its segments being more deeply shaded).

Thus it is seen that in very young embryos all the cells are meristematic, and no tissues are differentiated. The first tissue to differentiate is the dermatogen, the greater part of which is usually cut off immediately after the octant stage. Some time before the appearance of the cotyledons the dermatogen is completed by a contribution from the suspensor. The periblem and plerome, which are indistinguishable at the apex and grow from a common meristem during the greater part of their intraseminal development, become completely differentiated and grow from separate initials before the intraseminal development is completed.

It must be remembered that the development of the primary root of an embryo, in which the suspensor usually plays such an important part, is a very different thing from the development of a lateral root which is not modified by any suspensor contribution.

The suspensor presents some variation, as may be seen by comparing the figures of *pl. XVI.* After the suspensor has reached the three or four-celled condition, which it does at a very early stage, its cells stop dividing until the dermatogen is cut off to complete the dermatogen of the root. The middle cells of the suspensor, *i. e.*, the one or two cells below the hypophysis, then divide and sometimes give rise to eight or ten cells. The suspensor cell nearer the micropyle does not seem to divide.

A glance at such embryos as those represented in *figs. 71* and *73* will show that the development below the first transverse division of the embryo is more regular and symmetrical than that of the upper half. In the hypocotyledonary portion there is a zone of cells (*z*, *figs. 71, 73*) which is frequently quite conspicuous at this stage. Below this zone the same figures show that the arrangement may be somewhat symmetrical. Even in the upper part, an embryo as regular as that drawn in *fig. 71* shows some symmetry in the arrangement of its cells, but usually there is no regularity or symmetry except in the general outline. I have made no special study of the upper part of embryos older than that represented by this figure. The embryo loses its spherical or ovoid form, becomes flat across the top, two regions of more rapid cell division and growth appear which push the cotyledons up above the less active meristem of the main axis, and the embryo assumes the characteristic form shown in *fig. 66a*.

No account of Salix would be complete without mentioning peculiar embryos which depart from the normal course of development and for a time seem to have an apical cell. In one of these embryos (*fig. 61*) the apical cell is three-sided, and has cut off two segments in true pteridophyte fashion. A surface view of another is shown in *fig. 64*, and a median section of the same embryo is given in *fig. 63*, while still another peculiar embryo is shown in *fig. 62*. No trace of such apical cells is found in embryos older than these. If such embryos mature, it would be interesting to discover how the periblem and plerome differentiate, and what part the suspensor plays in the development.

TERATOLOGY.

Salix has been notable always for the frequency and variety of its sports. It is now monosporangiate and diœcious, but embryology gives no evidence that this is due to suppression, suggesting rather that it represents a primitive condition.

A vigorous plant of *S. glaucophylla* was found in the spring of 1895, many of the pistillate catkins of which were three or four inches long. A few catkins were entirely staminate, others were entirely pistillate, but many were mixed, some of the bracts having two stamens, some having one pistil, others having one pistil and one stamen, and still others having one pistil and two stamens. The pollen and stigmas matured at about the same time. Sections of the pistils showed perfectly normal conditions from the origin of the macrospore to the mature seed. The plant behaved the same way the next spring, and buds collected during the past winter showed that the same peculiarities will be continued. I have planted seeds to discover whether these characters can be propagated in that way.

A plant of *S. cordata* had some bracts with two pistils, and some with one pedicel bearing two pistils at its tip, but nearly all the bracts had the usual single pistil. No stamens were found upon this plant. Sections showed normal ovules and embryo development.

A plant of *S. petiolaris* found in the spring of 1896 exhibits the most surprising variety of sports. On this plant were found both staminate and pistillate catkins, catkins with pistils from some bracts and stamens from others, also catkins in which two stamens and one pistil, or one stamen and one pistil came from the axil of the same bract. Sections of material from this plant revealed interesting monstrosities, which are almost endless in their variety. For the sake of comparison, a section of a normal pistil of the same species, drawn to the same scale, is given in *fig. 78*. Sections like *fig. 83* were not uncommon. Externally this pistil seems perfectly normal, but at the base of the ovary there is a single ovule instead of the half-dozen or more which are expected in this species. The embryo sac shows a well developed egg apparatus and primary endosperm nucleus. A single erect microsporangium is borne upon a stalk which closely resembles the placenta which bears the ovules. In *fig. 88* there is external irregularity in the position of the stigma. The ovules are normal, one having a perfect embryo with the usual amount of endosperm, and the other having a well developed embryo sac. The single microsporangium is not borne upon a stalk, but nearly upon the wall of the carpel. In *fig. 79* there are four ovules at the base of the ovary, all with embryo sacs developed to the fertilization stage. At the upper part is an ovule placed transversely. The middle is occupied by four microsporangia of very different aspect, one being borne upon a long slender stalk, another just above it having a somewhat placental base and decidedly pointed apex, while one of those on the other side is borne on the wall of the carpel, and the other upon a placental growth developed at a fold in the carpel. In *fig. 82* there are two pistils upon a single pedicel, in one of which there is but a single poorly developed ovule, in the other two normal ovules and two microsporangia. In *fig. 85* the two pistils are united for half their length, one having two feebly developed microsporangia and one normal ovule, and the other the lower ovule perfectly orthotropous and with a perfect integument all around, its embryo sac being normal. This ovule is borne upon a long, smooth, slender stalk, which springs from the usual placental outgrowth. These long stalks were observed several times, and they always bore orthotropous ovules. It will be remembered that the anatropous or orthotropous character of ovules is used as a taxonomic character, the normal ovules of *Salix* being anatropous. The other ovule is anatropous, and presents nothing exceptional except that the placental outgrowth is elongated. Another orthotropous ovule is shown in *fig. 87*, one of the two microsporangia having a long stalk. In *fig. 86* one might fairly claim an ambisporangiate flower. The pistil contains two normal ovules, and one ovule curiously formed in the wall of the carpel, while the upper part of the ovary is occupied by two large microsporangia, one of which is not represented. The staminate flower, if such it may be called, has two microsporangia lying side by side, one of which is not represented. The stalk has the structure of a carpel wall rather than that of a filament. In *figs. 80, 81* we have utterly irregular conditions. The ovules are not at all enclosed in the ovary, three of them being borne transversely and one of them orthotropous. Two of the embryo sacs were normally developed and look as if they might produce embryos. This would afford an instance of fertilization in angiosperms without the intervention of a stigma. The pollen could fall directly upon the ovule and a very short pollen tube would suffice. Such open carpels are not rare in this plant and it is probable that a careful search would yield cases of fertilization and embryo formation. A curious case is shown in *fig. 84*, where a common stalk branches into two filaments, each bearing an anther. Each anther has four microsporangia, two longer and larger on the inner side, and two spherical ones on the other side of the connective. In the anther on the right, the connective is prolonged into a well developed stigma.

Examples might be multiplied almost indefinitely, but these illustrate the general direction of the irregularities. Monosporangiate and ambisporangiate flowers in Salix have been described before, but I can find no account of microsporangia borne inside the ovary, or of orthotropous ovules.

The more minute anatomy deserves some attention. As a rule, the macrospores have a perfectly normal development. Most of the material showed the macrosporangia at the fertilization period, and the egg apparatus and primary endosperm nucleus could not be distinguished from those of normal plants, and in several cases, as in *fig. 88*, embryos were developing in the usual way. The stamens of monosporangiate flowers, as well as those of the ambisporangiate flowers, developed exactly like other stamens in every detail which I was able to observe, but the microsporangia which were borne within the ovary need separate mention. These sporangia were usually solitary, but sometimes in pairs, and the wall usually had no layer at all between the tapetum and endothecium, the former often being abnormally developed, as in *fig. 3*. It is not at all unusual to find cells of the tapetum with two, three, or even four large nuclei, as represented in this figure. This preparation also shows cells of the tapetum which have divided by periclines. The cells of the sporogenous tissue are irregular in shape and probably would not have developed spores. Another irregular case is shown in *fig. 6*, where the sporogenous cells, probably spore mother cells, have surrounded themselves with a thick wall. Instances like *figs. 3* and *6* are common, where the sporangium development is feeble and seems to have been checked. Many of the microsporangia, however, especially those which are more or less stalked, present a more normal development. A characteristic example of the microsporangia which continue their development is seen in *fig. 7*, the wall appearing much like that in *fig. 8*, which is drawn from a perfectly normal anther of *S. cordata*. The pollen grains are somewhat vacuolated (as are the cells of the tapetum), and show the division into tube nucleus and generative nucleus, which are slightly smaller than is usually the case in *S. petiolaris*.

but the pollen grains in *fig. 5* could not be distinguished from normal ones at this stage. The pollen grains continue their development, the generative nucleus organizing a part of the surrounding cytoplasm and becoming the center of a fusiform cell (*fig. 4*). It is hardly probable that the pollen of these internal microsporangia plays any part in fertilization, for it is uniformly later in developing than the macrospores.

Those who regard Salix as a reduced type rather than a primitive one might consider this mixture of monosporangiate and ambisporangiate forms as favorable testimony, but they furnish better evidence that even such variations as a change from diœcism to monœcism or even to an ambisporangiate condition may appear suddenly. The orthotropous ovules and microsporangia inside of the ovary are also suggestive.

SALIX AND OTHER AMENTIFERÆ.

The occasional presence of more than one macrospore in Salix is in harmony with what is known of other Amentiferæ. A few preparations of early stages in *Populus tremuloides* show five or six cells which are elongated to three or four times the length of the surrounding ones, have richer contents, and appear to have equally good prospects of becoming macrospores.

The early development of the macrospore agrees more nearly with Nawaschin's Betula than with any other of the described Amentiferæ.

The tracheids, which form such a marked feature in Treub's Casuarina and Miss Benson's Castanea, do not occur in Salix.

Salix has no cæcum, unless the elongated antipodal end of the sac can be regarded as such. Cæca are so prevalent in Casuarina and the British Amentiferæ that Miss Benson says "they may fairly be regarded as of taxonomic value."

The embryo sac of Salix, at the fertilization period, differs from those of Alnus, Corylus, Betula, Carpinus, Juglans, and Myrica, in that these have antipodals which may be found with some ease, in some of them the antipodals being quite persistent and forming thick cellulose walls. I am inclined to think that

Treub's Casuarina agrees with Salix in that its antipodals are also hard to find. Treub states that they do not exist, and in claiming the development of an embryo sac without antipodals he has certainly given us something unique. Treub's main work was upon the sporogenous tissue, sterile macrospores, and chalazogamy, and his results here are unquestionable; but it might be worth while to have the development of the macrospore worked out in detail.

With the exception of the problematical case represented in *fig. 31*, nothing was observed which would suggest the formation of endosperm before the entrance of the pollen tube. In Casuarina, as described by Treub (22), the endosperm is formed before fertilization, and does not have its origin in a primary endosperm nucleus formed by fusion of polar nuclei. If Casuarina has no primary endosperm nucleus, the mode of origin of the endosperm is also unique. The formation of endosperm before fertilization is not at all unusual, if fertilization be defined strictly as the fusion of the sex cells. In general the division of the primary endosperm nucleus precedes the division of the oospore as frequently as it follows, and it is not exceptional to find two or four nuclei in the endosperm before the division of the oospore, but in all these cases the formation of endosperm seems to be initiated through the influence of the pollen tube. Since Treub's figures show the pollen tube within the macrospore he may have merely an unusual amount of endosperm formed before the fusion of the sex cells. It is certainly true that Casuarina has a more extensive endosperm formed before the division of the oospore than has yet been described for any other angiosperm, Myrica somewhat approaching it in this respect. Unfortunately I have had no opportunity to examine any preparation of Casuarina.

RECAPITULATION AND SUMMARY.

Complete series were studied in *Salix glaucophylla*, *S. petiolaris*, *S. cordata*, and *S. tristis*, with less complete series in thirteen other species.

1. *Organogeny of the flower.*—Pistillate buds, collected in August show the carpels outlined but no trace of ovules. October buds of *S. glaucophylla* and *S. cordata* show the nucellus, but the integument as a rule does not appear until spring. Staminate buds collected in October show the stamens well outlined. The nectaries in both staminate and pistillate buds can be seen in October. A diligent search failed to reveal the slightest trace of rudimentary floral organs, which those who regard Salix as a reduced type might expect to find.

2. *Development of the microspores.*—A comparison of autumn, winter, and early spring buds shows that most stamens pass the winter in the spore mother cell stage. The division into generative nucleus and tube nucleus takes place before the tapetum breaks down. The generative nucleus soon organizes a part of the surrounding cytoplasm and becomes a fusiform cell. No wall is formed between the nuclei. *Populus monilifera* differs in this respect, a definite wall separating the two cells. The cells of the tapetum are often binucleate.

3. *Origin of the macrospore.*—The macrospore has its origin in a hypodermal cell at the apex of the nucellus. Sometimes there are two or three archesporial cells, but it is very seldom that more than one develops. The primary tapetal cell usually gives rise to a tier of three or four cells, but sometimes does not divide. The macrospore mother cell usually cuts off one or two potential macrospores, but sometimes germinates without cutting off any such cells. This variation is prevalent in the genus.

4. *Germination of the macrospore.*—The first division of the primary nucleus of the macrospore is transverse. In the second and third divisions the spindles at the micropylar end are transverse, while the spindles at the antipodal end are longitudinal. After the first division, development proceeds with increasing rapidity until the female gametophyte has reached the fertilization period. Great difficulty was experienced in demonstrating the presence of antipodal cells, several hundred macrospores, just before the fertilization period, yielding only six cases of

undoubted antipodals. This might suggest that Casuarina may have antipodals which are also evanescent and hard to find.

The synergids frequently have a strongly developed "filiform apparatus," which gives them a beaked appearance. The egg apparatus breaks through the wall of the macrospore and projects into the micropyle. In a few cases the synergids were observed to persist until the embryo was almost in the cotyledon stage.

5. *The pollen tubes and fertilization.*—The pollen tubes were examined with great care in several species on account of the discovery of chalazogamy in several of the Amentiferæ, but in every case the pollen tube was observed to enter the micropyle. The beaks of the synergids open the micropyle and attract the pollen tube.

The generative nucleus was observed in the pollen tube and in the oosphere, but not in the act of fusion. The polar nuclei fuse to form the primary endosperm nucleus before the fusion of sex cells takes place. As soon as the pollen tube enters the micropyle the primary endosperm nucleus begins to enlarge, and its division usually precedes that of the oospore. In one case the embryo had almost reached the cotyledon stage and the primary endosperm nucleus had not yet divided.

6. *Development of the embryo.*—The first division of the oospore is always transverse and that of the embryo cell is always longitudinal. The second division is usually longitudinal, but sometimes transverse, and the third division usually transverse but sometimes longitudinal. The differentiation of dermatogen usually immediately follows the octant state. The first pericline cutting off dermatogen appears in one quadrant as frequently as in another. Sometimes an octant will make one or two other divisions before the dermatogen is cut off. The dermatogen of the root tip is contributed by the upper cell of the suspensor. The suspensor does not contribute anything to the periblem. Periblem and plerome cannot be distinguished in early stages, as in Capsella. For a time, periblem and plerome grow from a common meristem, but toward the close of intra-

seminal development they become differentiated even at the apex and grow from separate initials.

7. *Teratology.*—In addition to monosporangiate and ambisporangiate forms, which have been described by other observers, a strange sport of *S. petiolaris* was found with microsporangia growing within the ovary. Sometimes the microsporangia were upon long stalks, sometimes upon placentalike outgrowths of the carpel, and sometimes imbedded in the carpel wall. One case showed two quadrilocular stamens with the filaments united below, and the connective prolonged above into a stigma. In the microsporangia borne inside the ovaries the microspore development was sometimes normal, but was as often feeble and abortive. In ovaries which contained microsporangia the ovules were sometimes perfectly orthotropous, and had the integument developed all around. The macrospore development was normal and embryos were not uncommon. Collections, representing in some cases three flowering seasons, show that a plant may continue its particular sport year after year.

8. *Salix and other Amentiferæ.*—Salix does not have the extensive archesporial tissue in the ovule described for several Amentiferæ, but sometimes has two or three archesporial cells. The development of the macrospore agrees more nearly with Betula than with any other of the described Amentiferæ. There are no nucellar tracheids as in Castanea and Casuarina. The difficulty in finding antipodals in Salix would suggest that the development of the macrospore in Casuarina be reinvestigated.

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EXPLANATION OF PLATES XII–XVIII.

List of abbreviations used: *a*, antipodals; *b*, beak, or filiform apparatus; *c*, root cap; *d*, dermatogen: *em*, embryo; *en*, primary endosperm nucleus; *m*, macrospore mother cell; *mg*, male generative cell; *o*, oosphere; *on*, oosphere nucleus; *per*, periblem; *pl*. plerome; *pt*, pollen tube; *syn*. synergid; *t*, tapetal cell.

All figures, except those of *pl. XVIII* and *fig. 66a*, were drawn with a $\frac{1}{12}$ Bausch and Lomb immersion and Zeiss ocular no. 4.

Figs. 1–9, × 594; figs. 10–24, × 631; figs. 25–65, × 694; figs. 66–77*a*, × 390; figs. 78–88, × 40.

PLATE XII.

FIG. 1. Young anther of *Salix glaucophylla*. October 1.

FIG. 2. Young anther of *Salix tristis*. March 31.

FIG. 3. *S. petiolaris*. Young microsporangium of a sport.

FIG. 4. *S. petiolaris.* Mature pollen grains of a sport.

FIG. 5. *S. petiolaris.* Portion of microsporangium of sport.

FIG. 6. *S. petiolaris.* Portion of microsporangium of sport. Irregular development.

FIG. 7. *S. petiolaris.* Portion of microsporangium of sport.

FIG. 8. *S. cordata.* Portion of microsporangium of normal anther.

FIG. 9. *S. cordata.* Later stage of development than *fig. 8.*

PLATE XIII.

S. glaucophylla.

FIG. 10. Apex of nucellus with single archesporial cell.

FIG. 11. Apex of nucellus with two archesporial cells.

FIG. 12. Apex of nucellus before the differentiation of the archesporium.

FIG. 13. Nucellus showing macrospore mother cell and primary tapetal cell.

FIG. 14. Typical nucellus with one fertile macrospore, one potential macrospore and three tapetal cells. The nucleus of the fertile macrospore is accompanied by two centrosomes.

FIG. 15. First division of the primary nucleus of the macrospore; one potential macrospore; two tapetal cells.

FIG. 16. Second division; one potential macrospore; one tapetal cell.

FIG. 17. One fertile macrospore; two potential macrospores; four tapetal cells.

FIGS. 18, 19. First division; one potential macrospore; three tapetal cells.

FIG. 20. Second division, showing transverse micropylar spindle and longitudinal antipodal spindle.

FIG. 21. Irregular development of macrospore.

FIG. 22. Irregular development; the micropylar nucleus has probably not divided.

FIG. 23. Third division showing position of spindles. One spindle or pair of nuclei has washed out.

FIG. 24. Second division; unusual destruction of nucellar tissue for this stage.

PLATE XIV.

FIG. 25. *S. glaucophylla.* Oosphere indefinite in form; nucleolus of primary endosperm nucleus very dense; synergid nuclei distinct; filiform apparatus well developed.

FIG. 26. *S. glaucophylla.* Antipodal region; three definite antipodals.

FIG. 27. *S. glaucophylla.* Three antipodals; fusion of polar nuclei to form primary endosperm nucleus; one synergid with two nuclei.

FIG. 28. *S. petiolaris.* Egg apparatus projecting from nucellus; the synergids sharply beaked.

FIG. 29. *S. glaucophylla.* Extreme development of the beak or "filiform apparatus."

FIG. 30. *S. petiolaris.* Egg apparatus projecting; filiform apparatus feebly developed.

FIG. 31. *S. glaucophylla.* Cells marked *a* may be three antipodals; primary endosperm nucleus apparently not divided; if not antipodals the three cells may have resulted from the lower polar nucleus and the nucleus (*en*) may not be the result of fusion.

PLATE XV.

FIG. 32. *S. glaucophylla.* Just after fertilization; oospore is enlarged and has cellulose wall; endosperm nucleus not yet divided.

FIG. 33. *S. petiolaris.* Three cells marked *a* may be antipodals, or may explained as in *fig. 31.*

FIG. 34. *S. petiolaris.* Pollen tube has entered but fusion has not yet taken place; endosperm nucleus has become very large.

FIG. 35. *S. petiolaris.* Synergid persisting long after fertilization.

FIG. 36. *S. petiolaris.* Pollen tube entering between beaks of synergids; fusion not yet effected; primary endosperm nucleus very large.

FIG. 37. *S. glaucophylla.* Primary endosperm nucleus not yet divided, an abnormal delay.

FIG. 38. *S. glaucophylla.* Unusual persistence of synergids; synergids have no vacuoles and their nuclei are in an unusual position; the pollen tube, of course, is not the one which was concerned in fertilization; endosperm forming in the usual manner.

FIG. 39. *S. petiolaris.* Pollen tube between beaks of synergids; fusion has taken place, oospore very spherical; primary endosperm nucleus not yet divided.

FIG. 40. *S. glaucophylla.* Entrance of male generative nucleus; this nucleus is lenticular and its volume is less than that of the oosphere nucleus, although the figure gives a contrary impression.

PLATE XVI.

FIG. 41. *S. petiolaris.* First division of oospore.

FIG. 42. *S. glaucophylla.* First division of oospore.

FIG. 43. *S. petiolaris.* The suspensor cell has divided.

FIGS. 44–46. *S. petiolaris.* First division of the embryo.

FIG. 47. *S. petiolaris.* Embryo of three cells; upper cell of suspensor has divided.

FIG. 48. *S. petiolaris.* Quadrant stage; second division of the embryo has been transverse; all nuclei are shown; synergid persisting.

FIG. 49. *S. cordata.* Quadrant stage; second division of embryo longitudinal.

FIG. 50. *S. petiolaris.* Quadrant stage; second division of embryo longitudinal.

FIGS. 51, 52. Quadrant stages in *S. petiolaris* and *S. cordata* respectively.

FIG. 53. *S. petiolaris.* Octant stage; upper cell of suspensor has given rise to a plate of four cells; synergid persisting.

FIG. 54. *S. petiolaris.* Quadrant stage; embryo small as compared with the suspensor.

FIG. 55. *S. petiolaris.* Irregular embryo.

FIG. 56. *S. cordata.* Dermatogen cut off in one segment while a neighboring segment is developing farther before cutting off dermatogen.

FIG. 57. *S. petiolaris.* Lower cell of suspensor much enlarged.

FIG. 58. *S. cordata.* Irregular embryo.

FIG. 59. *S. petiolaris.* Embryo of sport; variation in the stage at which dermatogen is cut off.

FIG. 60. *S. cordata.* Early division in middle cell of suspensor.

FIG. 61. *S. petiolaris.* Three-sided apical cell.

FIG. 62. *S. cordata.* Apical cell.

FIG. 63. *S. cordata.* Later stage of embryo which started to develop by an apical cell.

FIG. 64. Surface view of same embryo as *fig. 63.*

FIG. 65. *S. glaucophylla.* All dermatogen cut off except the suspensor contribution; sixteen cells in the embryo besides the dermatogen.

PLATE XVII.

FIG. 66. *S. tristis.* Root end of nearly mature embryo, showing character of various cells; periblem and plerome not entirely differentiated at the apex.

FIG. 66*a*. Outline sketch of same embryo showing cotyledons and apex of stem.

FIG. 67. *S. tristis.* Periblem and plerome differentiated even at the apex; initial cell of plerome and one segment more deeply shaded; dermatogen and four layers of root cap also shown.

FIG. 68. *S. glaucophylla.* Embryo before differentiation of the dermatogen of the root tip.

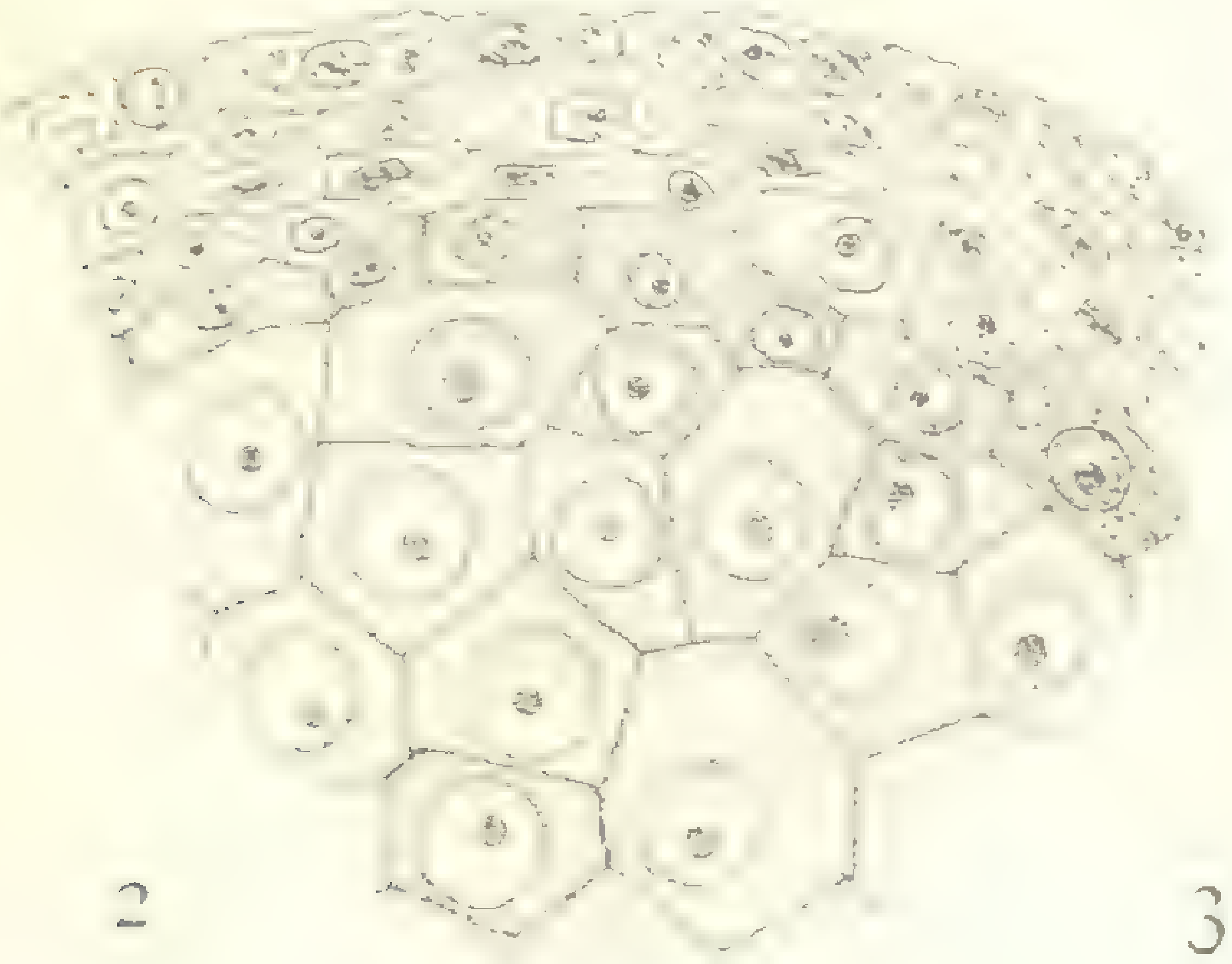
FIG. 69. *S. tristis.* Transverse section of embryo in the stage shown in *fig. 66,* taken a few cells above the common meristem of periblem and plerome.

FIG. 70. *S. glaucophylla.* Embryo unusually symmetrical in its divisions.

FIG. 71. *S. glaucophylla.* Very symmetrical embryo showing the zone of cells (*z*) just below the first transverse wall.

FIG. 72. *S. tristis.* Dermatogen of root tip differentiated; no trace of separation into periblem and plerome.

FIG. 73. *S. glaucophylla.* Embryo showing zone of cells (*z*); development more symmetrical in hypocotyledonary portion than in the cotyledonary.



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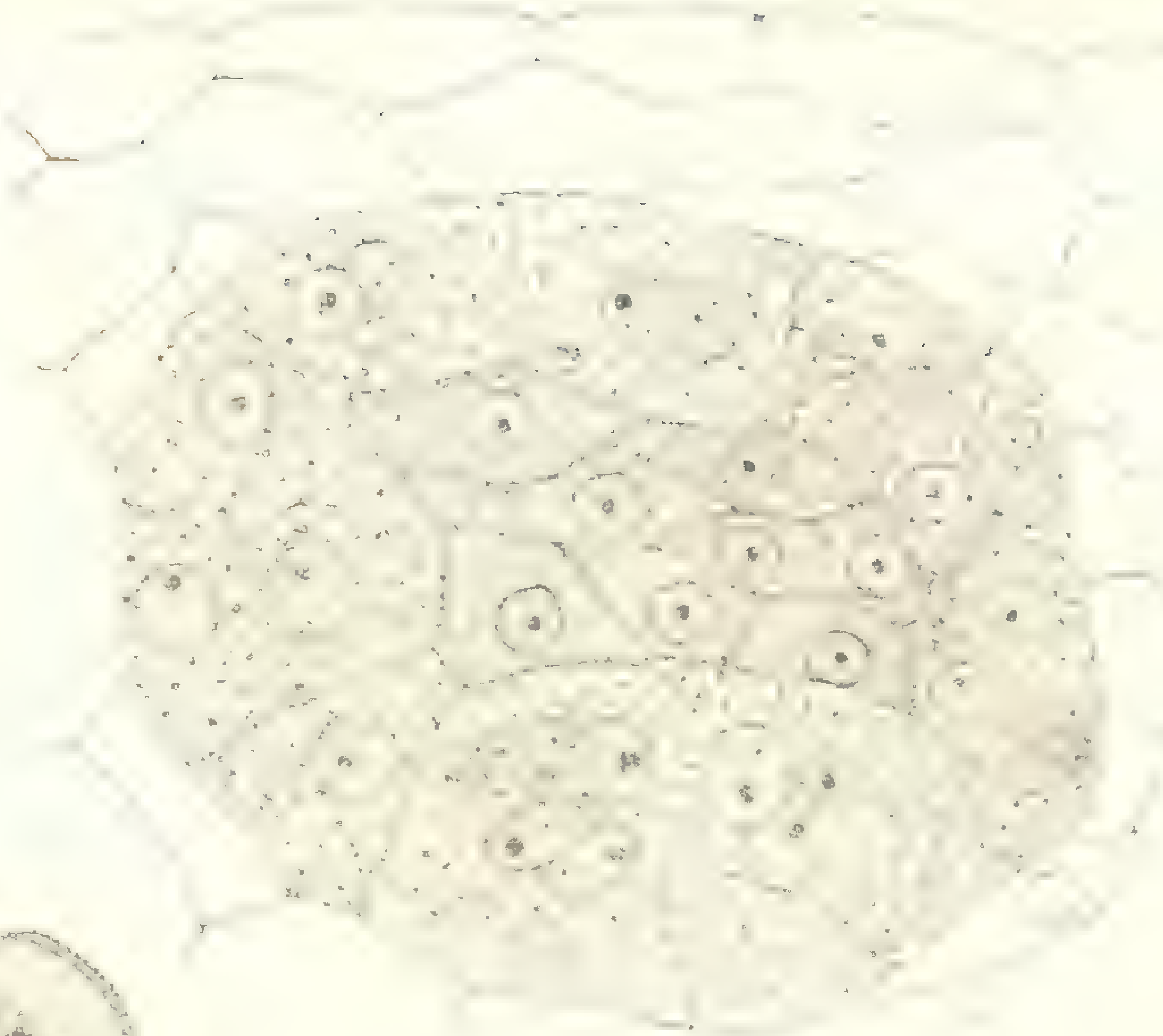

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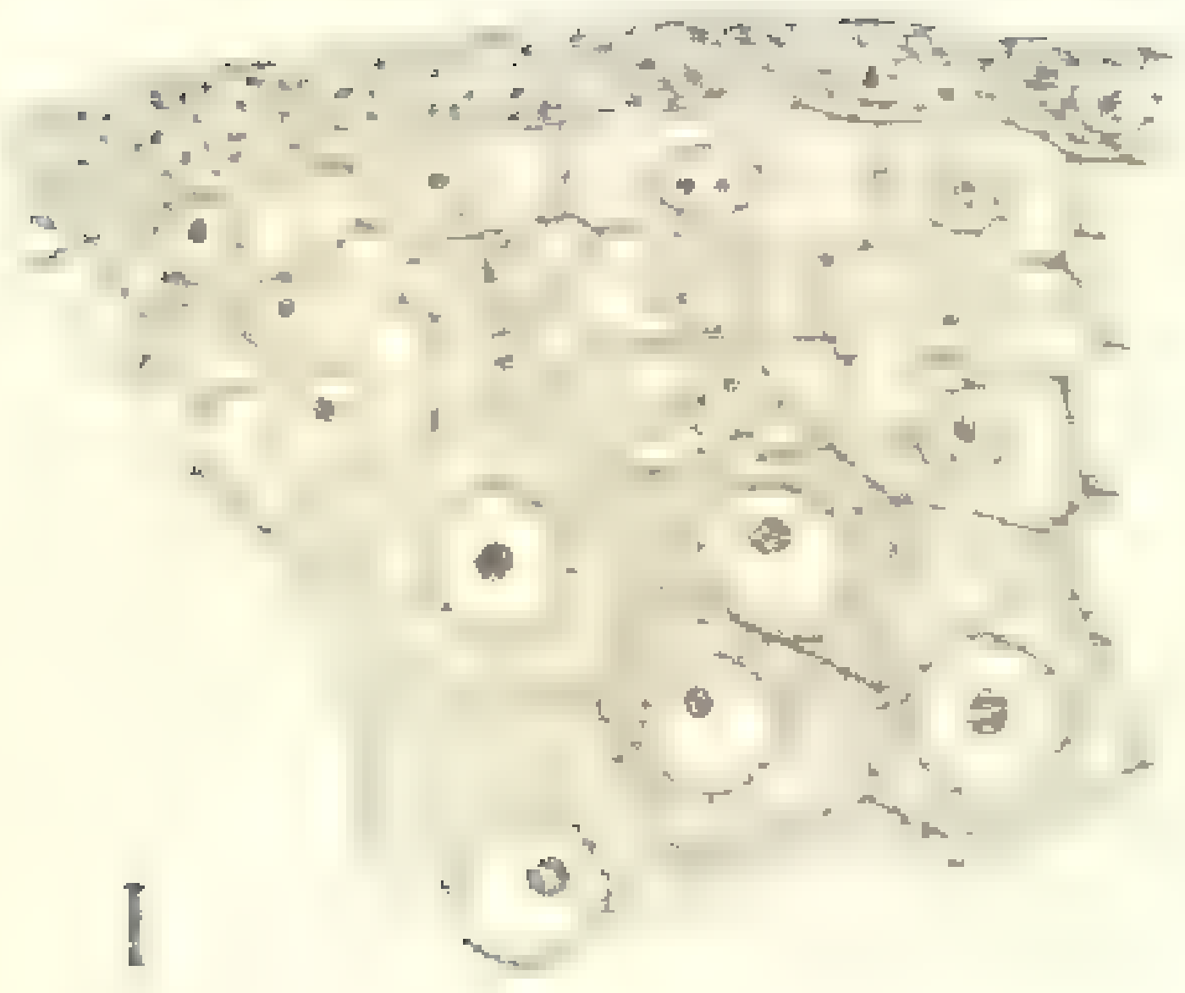

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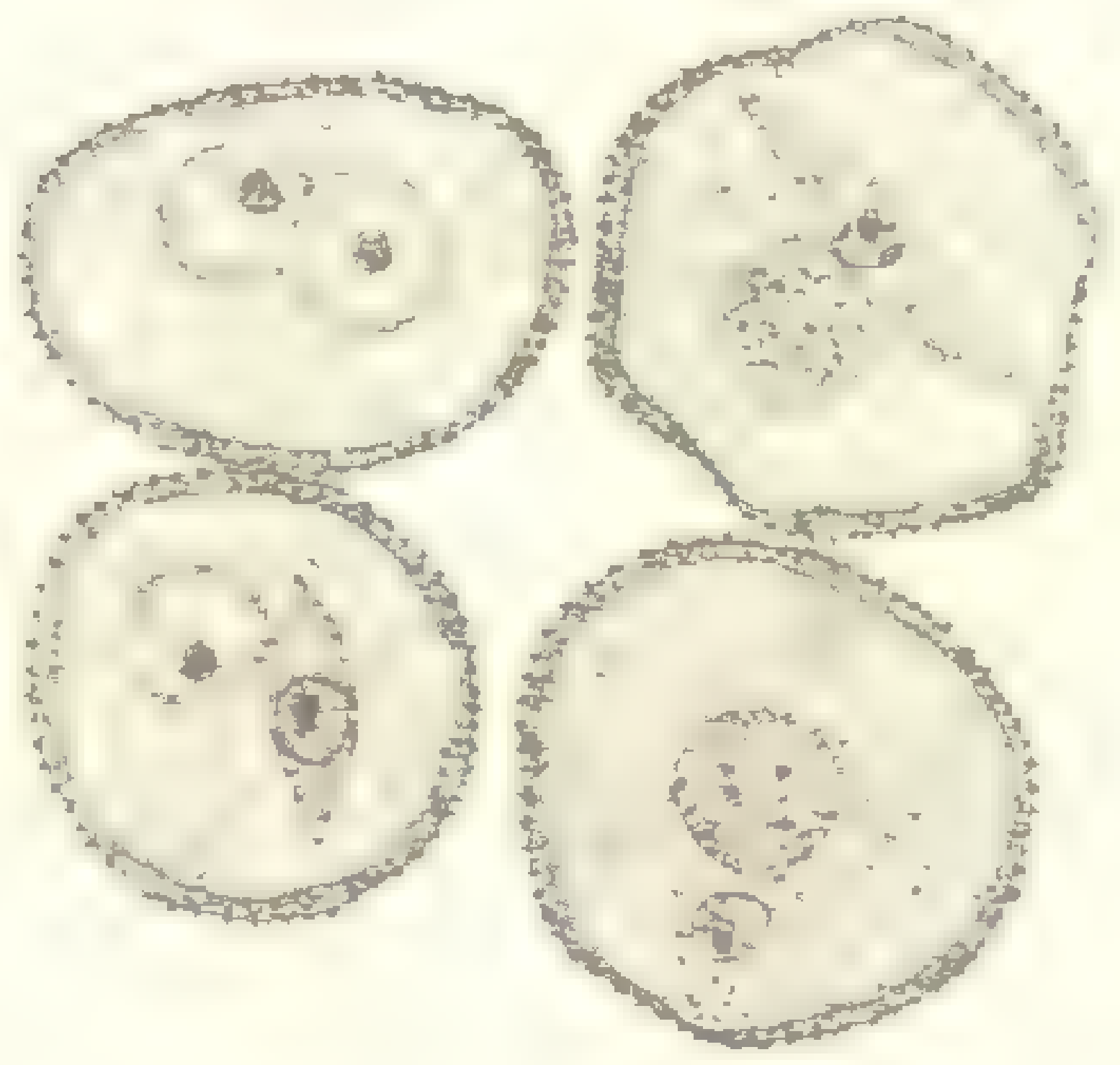

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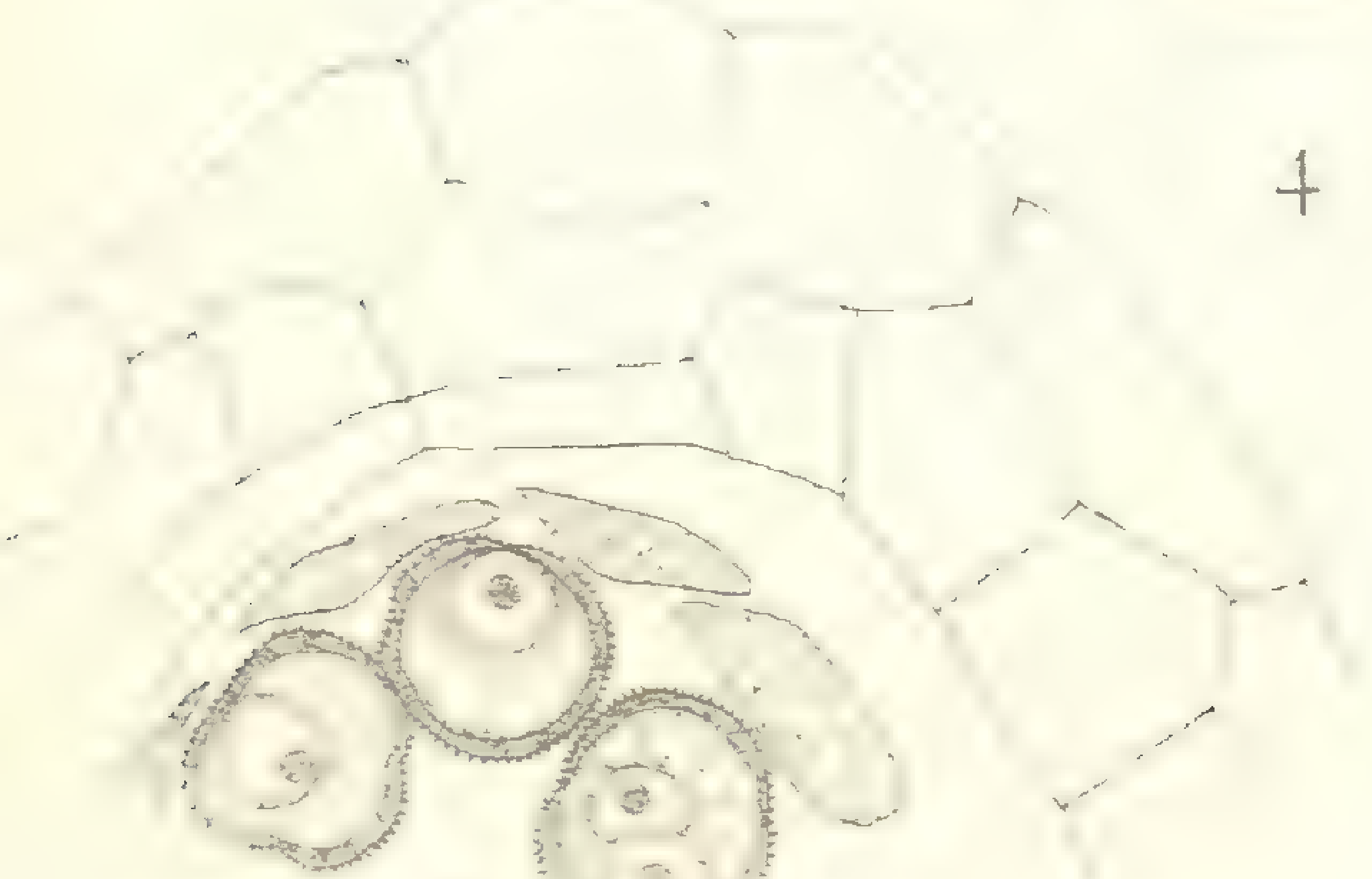

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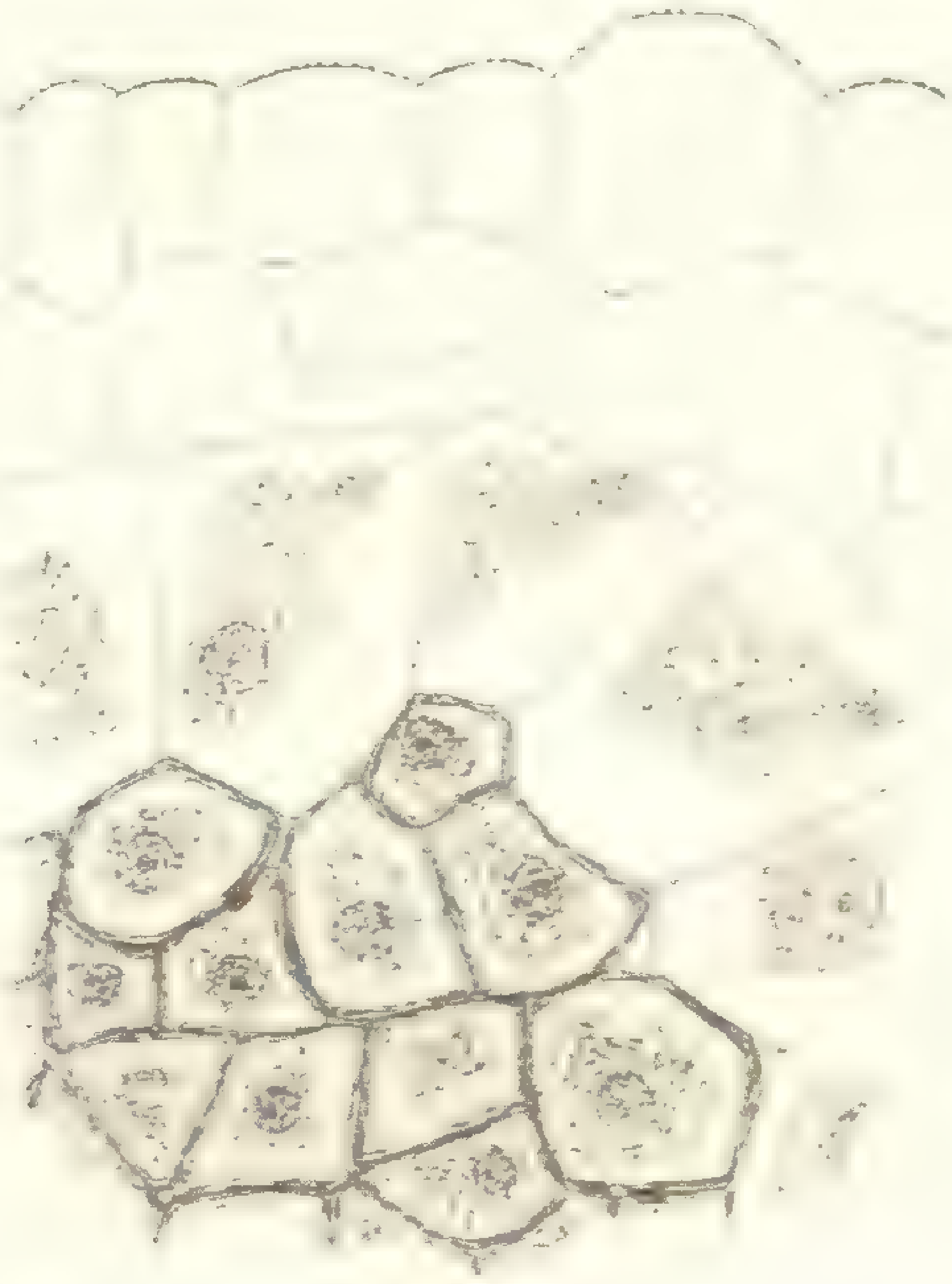

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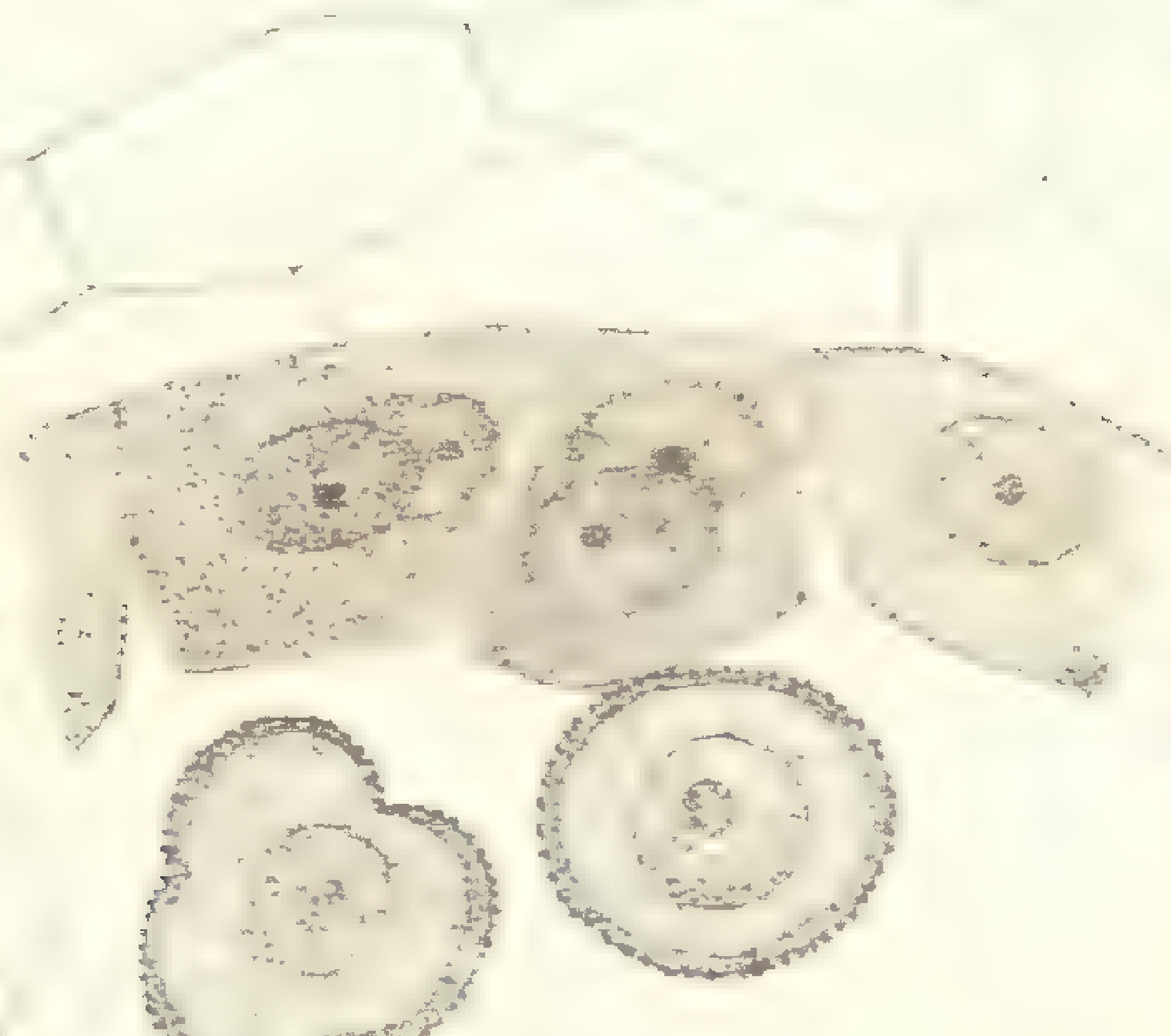

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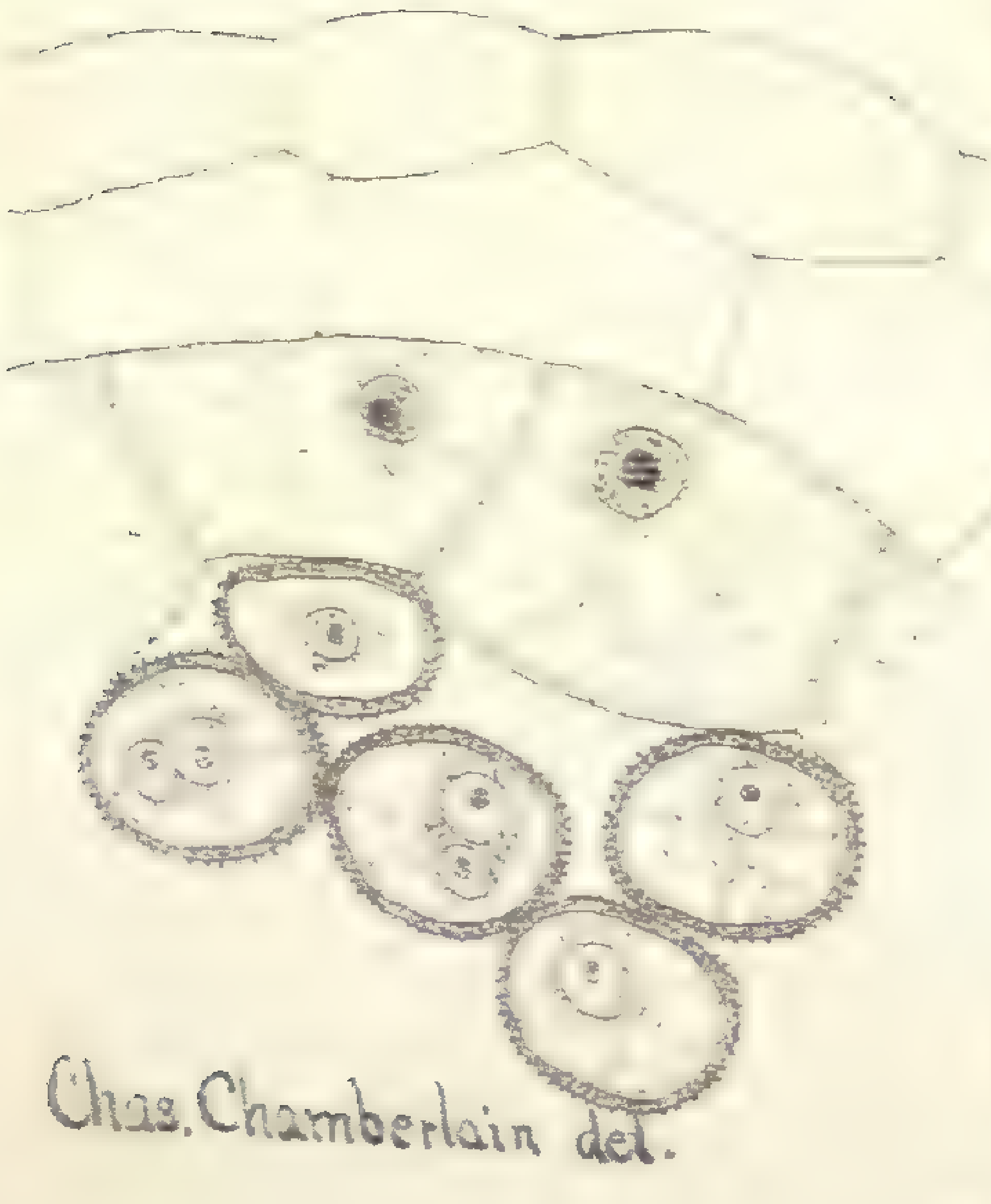

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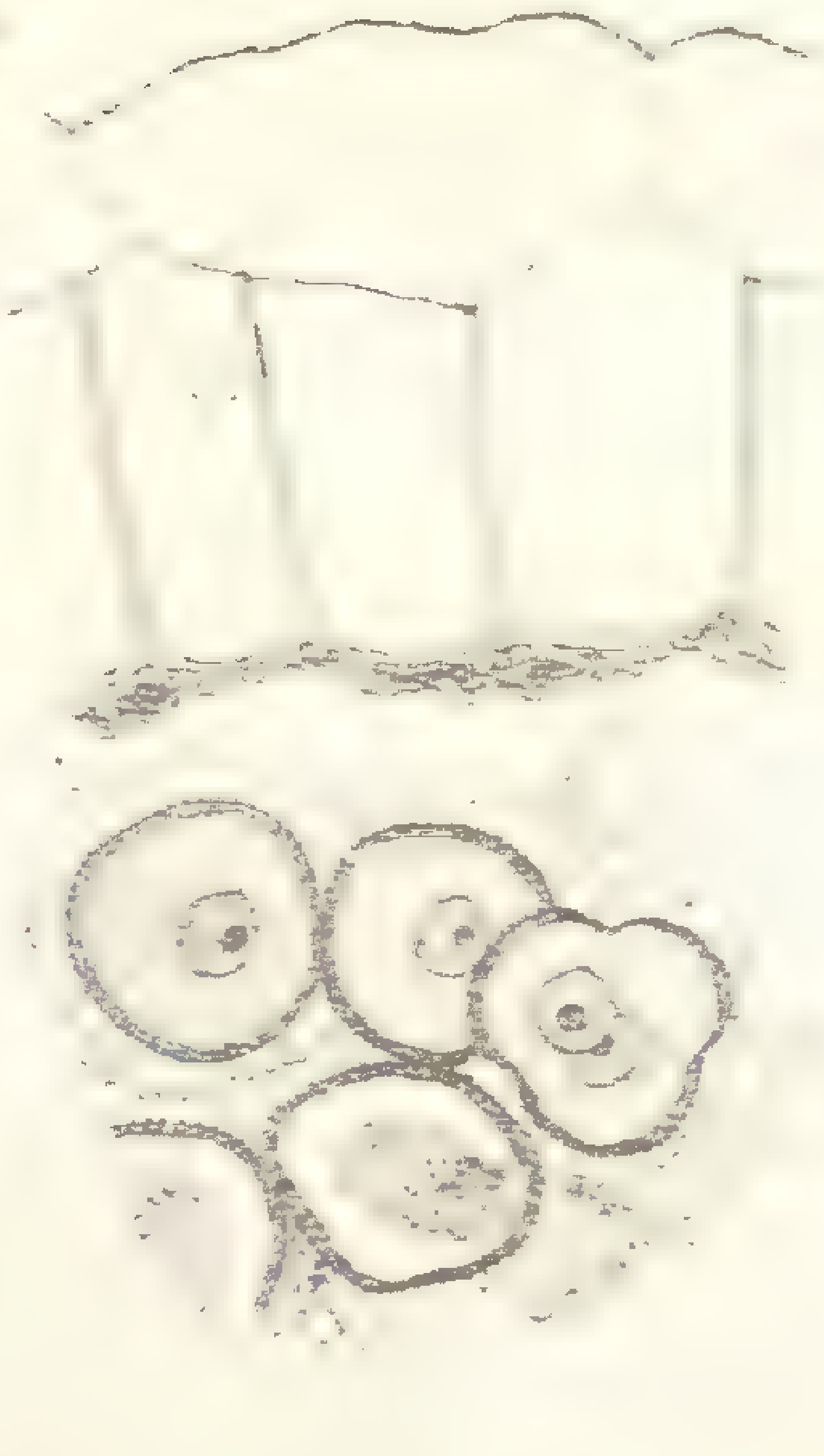

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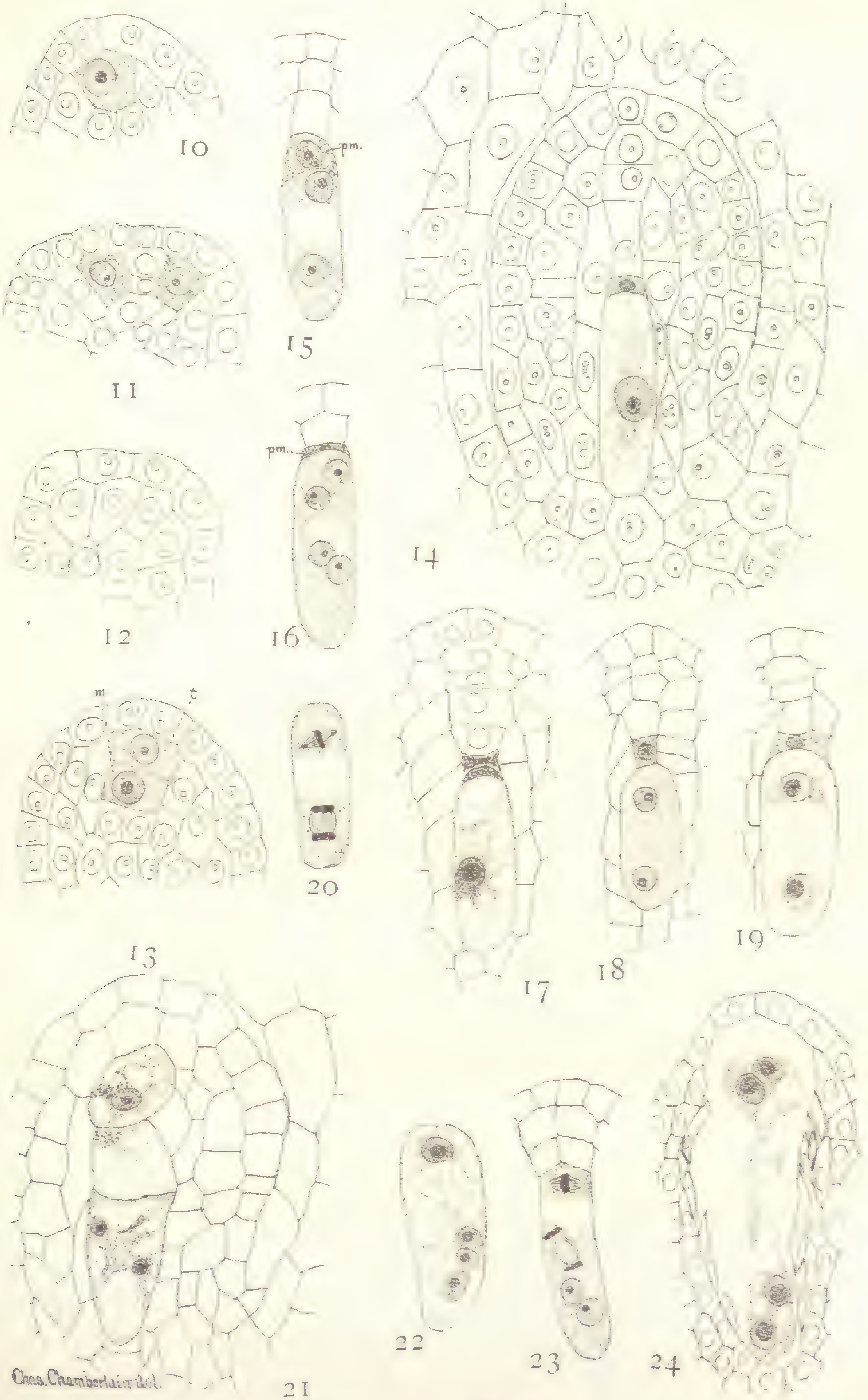
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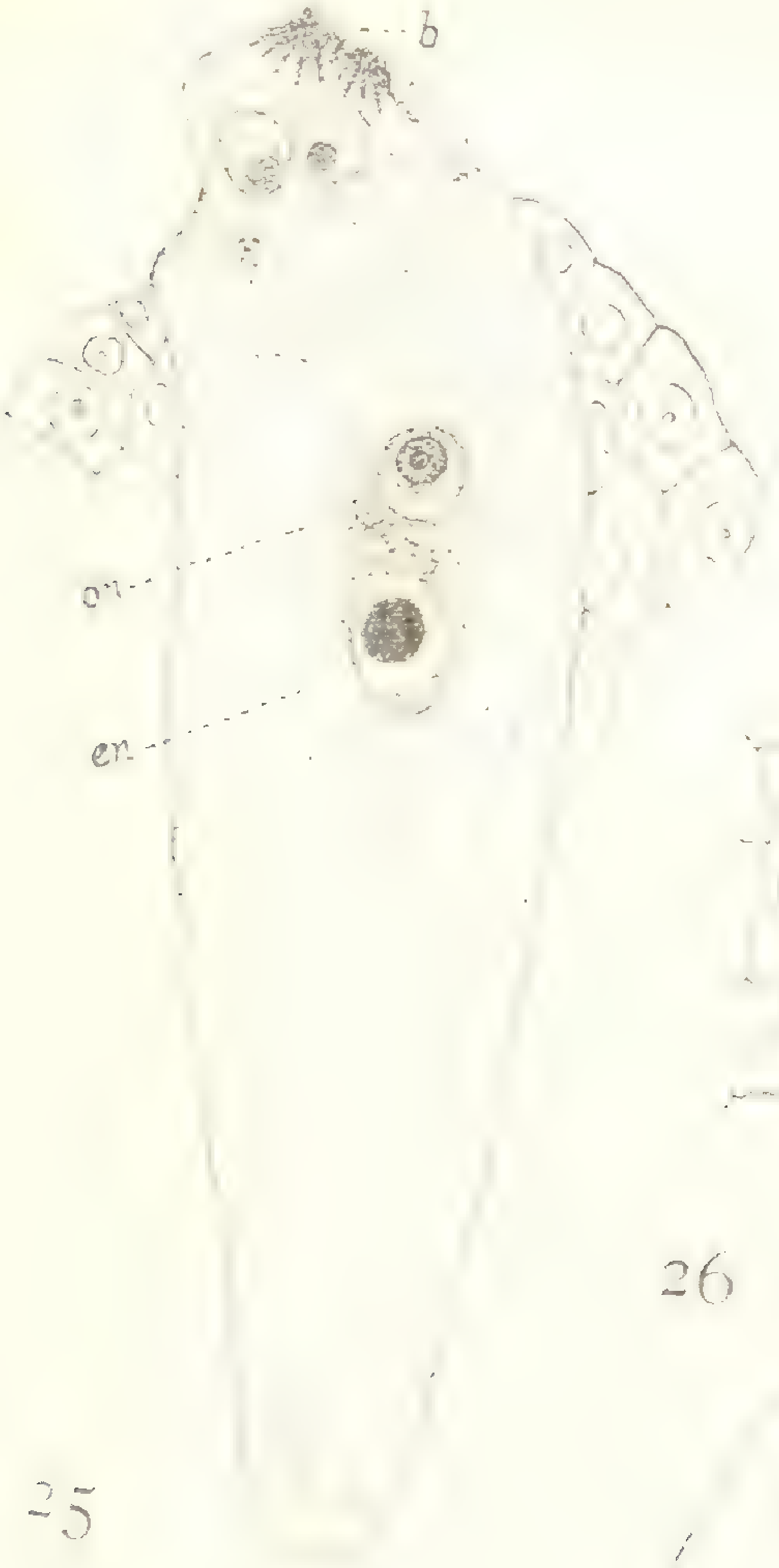

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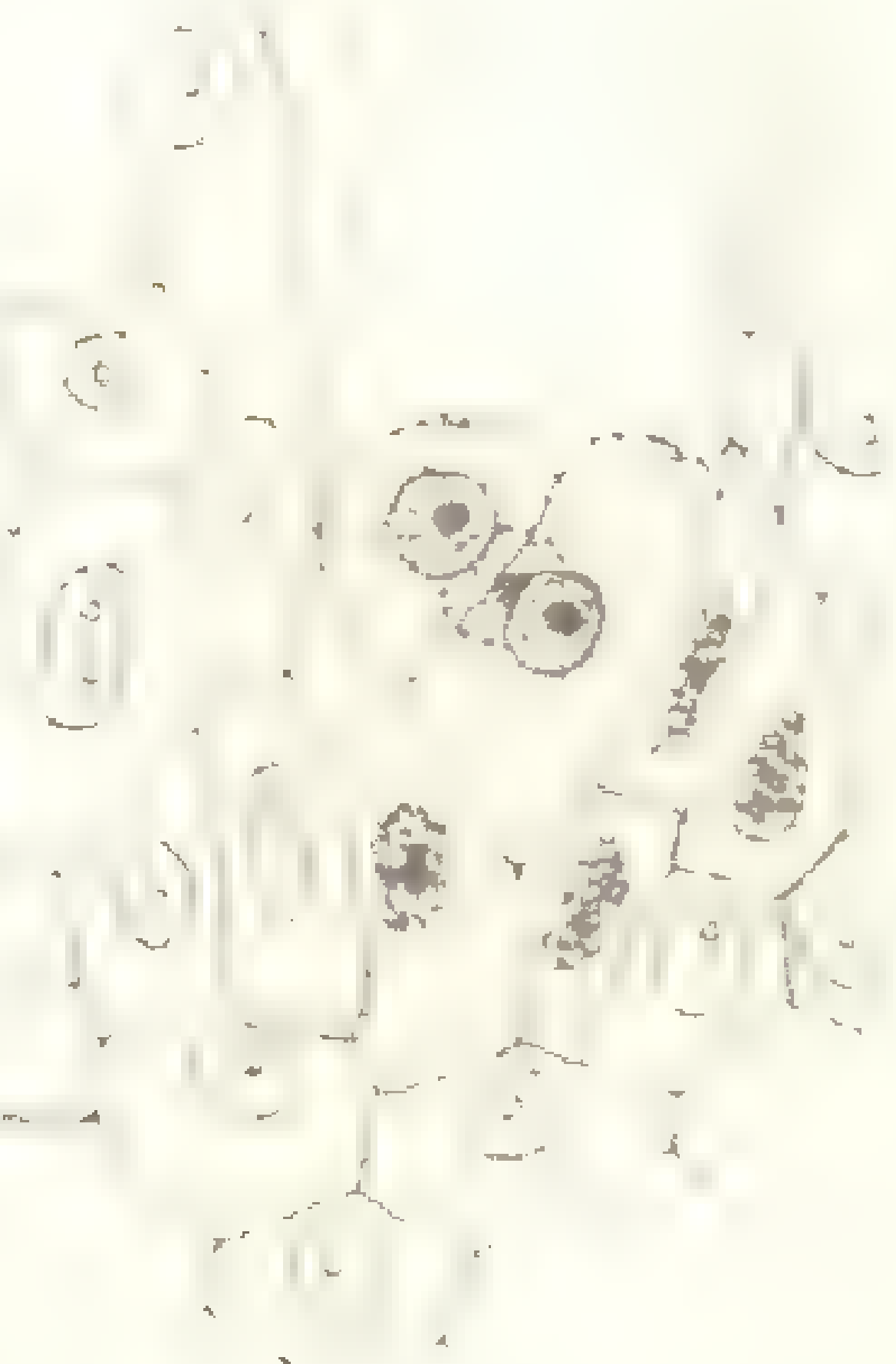

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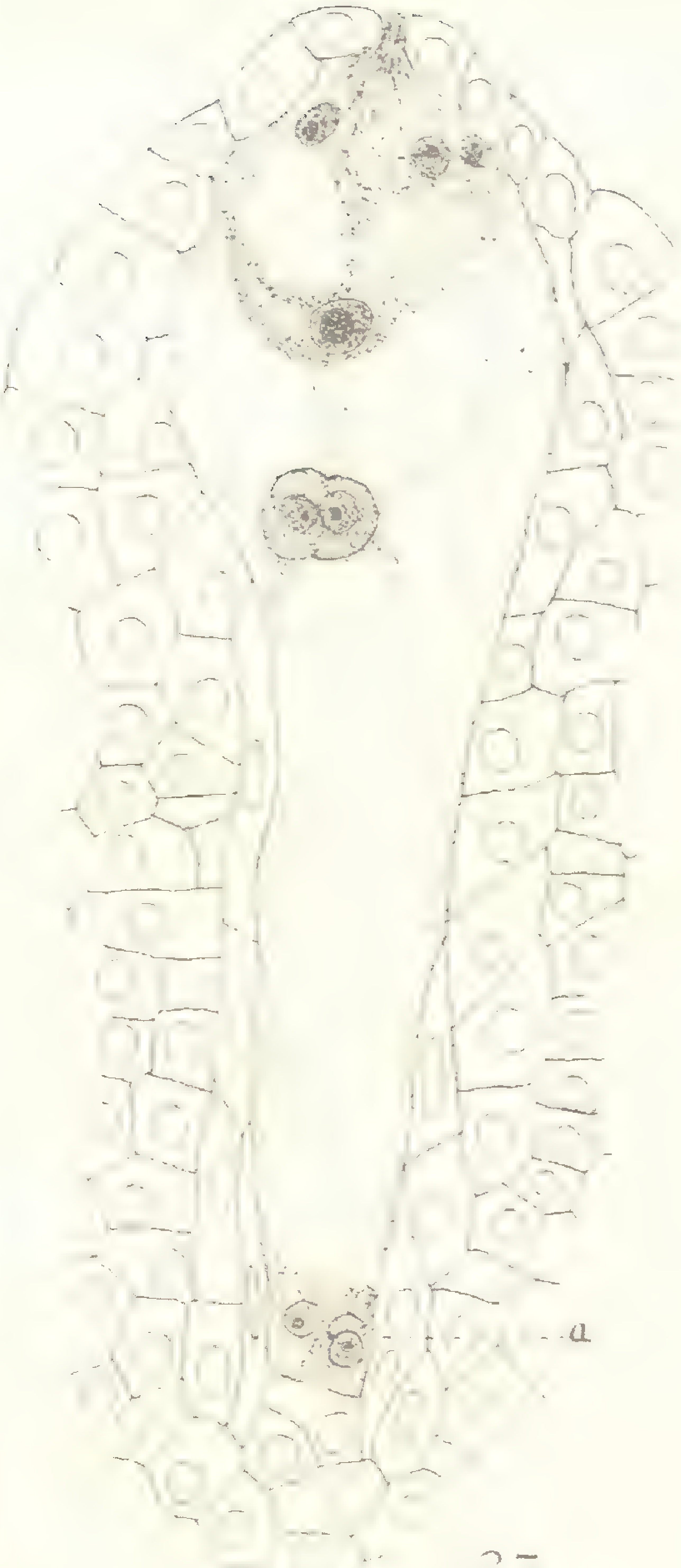

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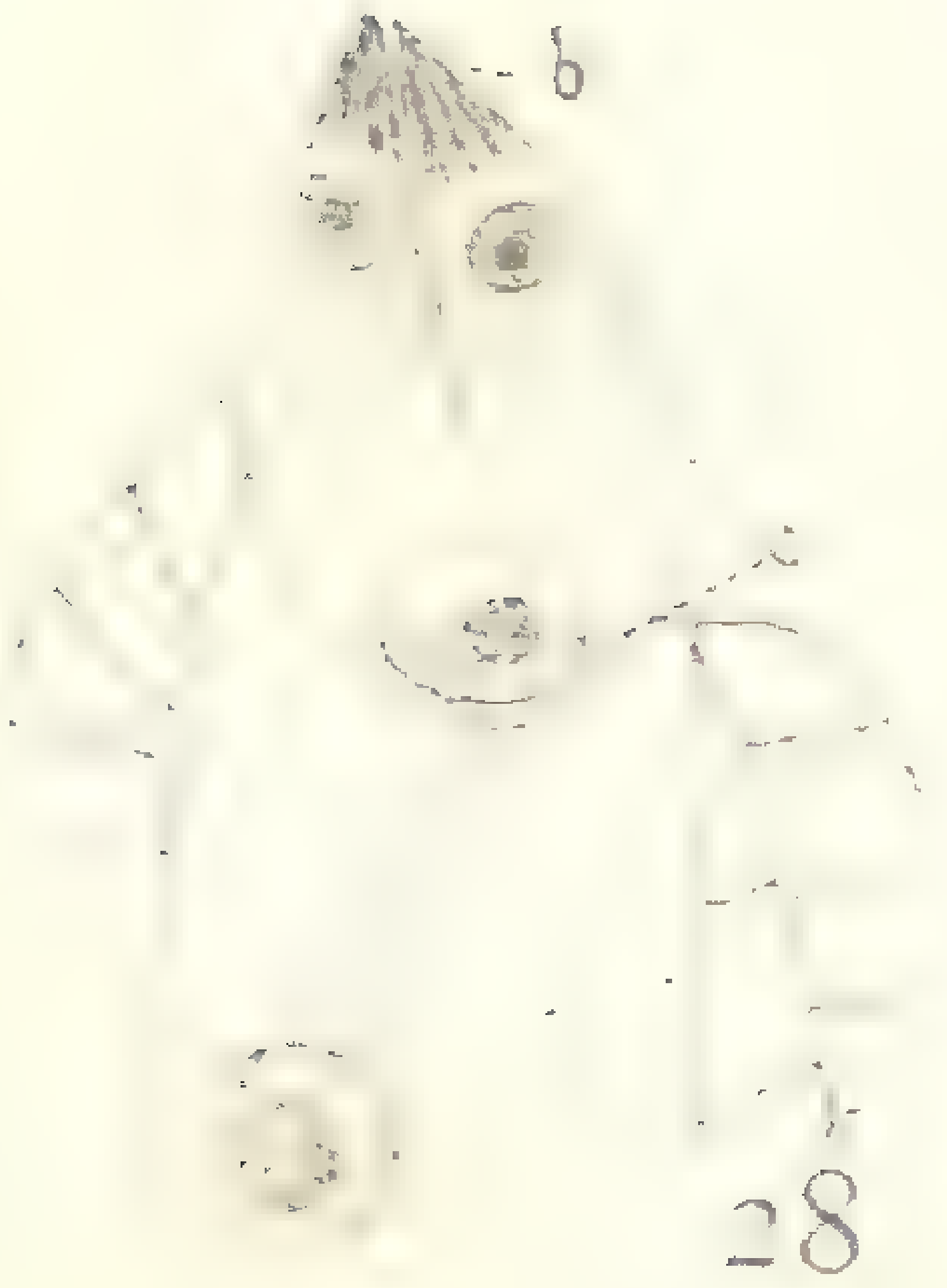

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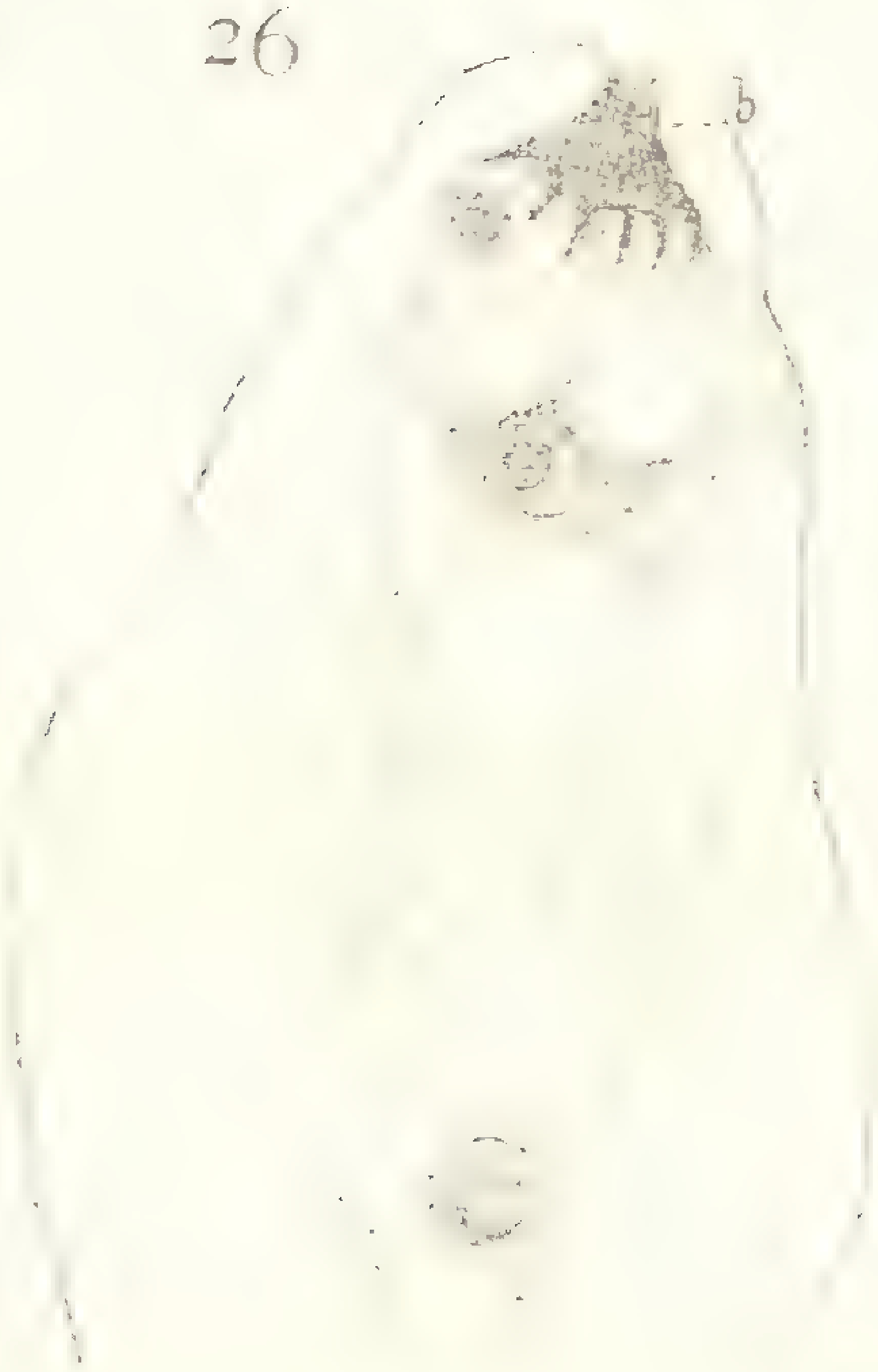

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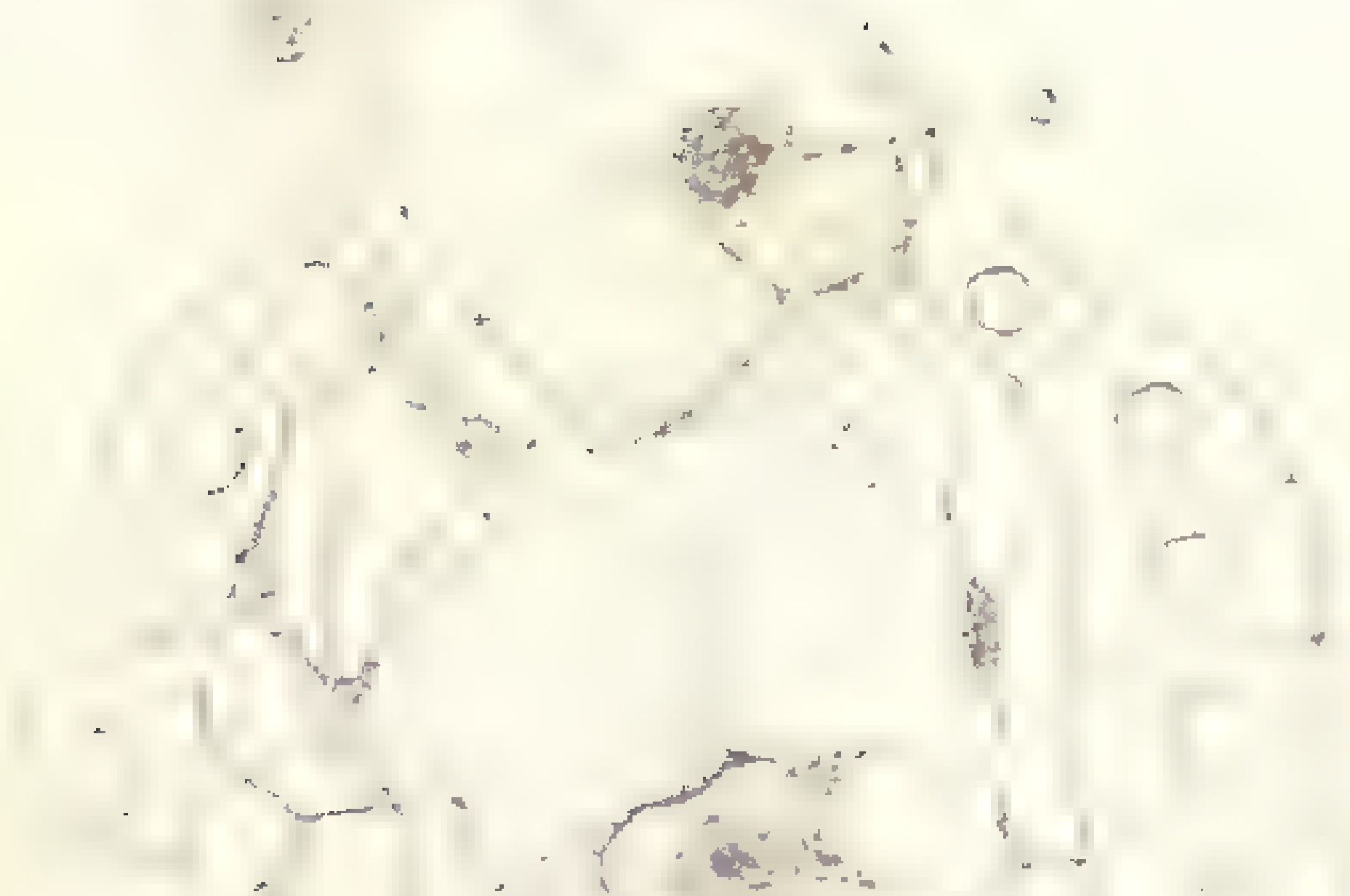

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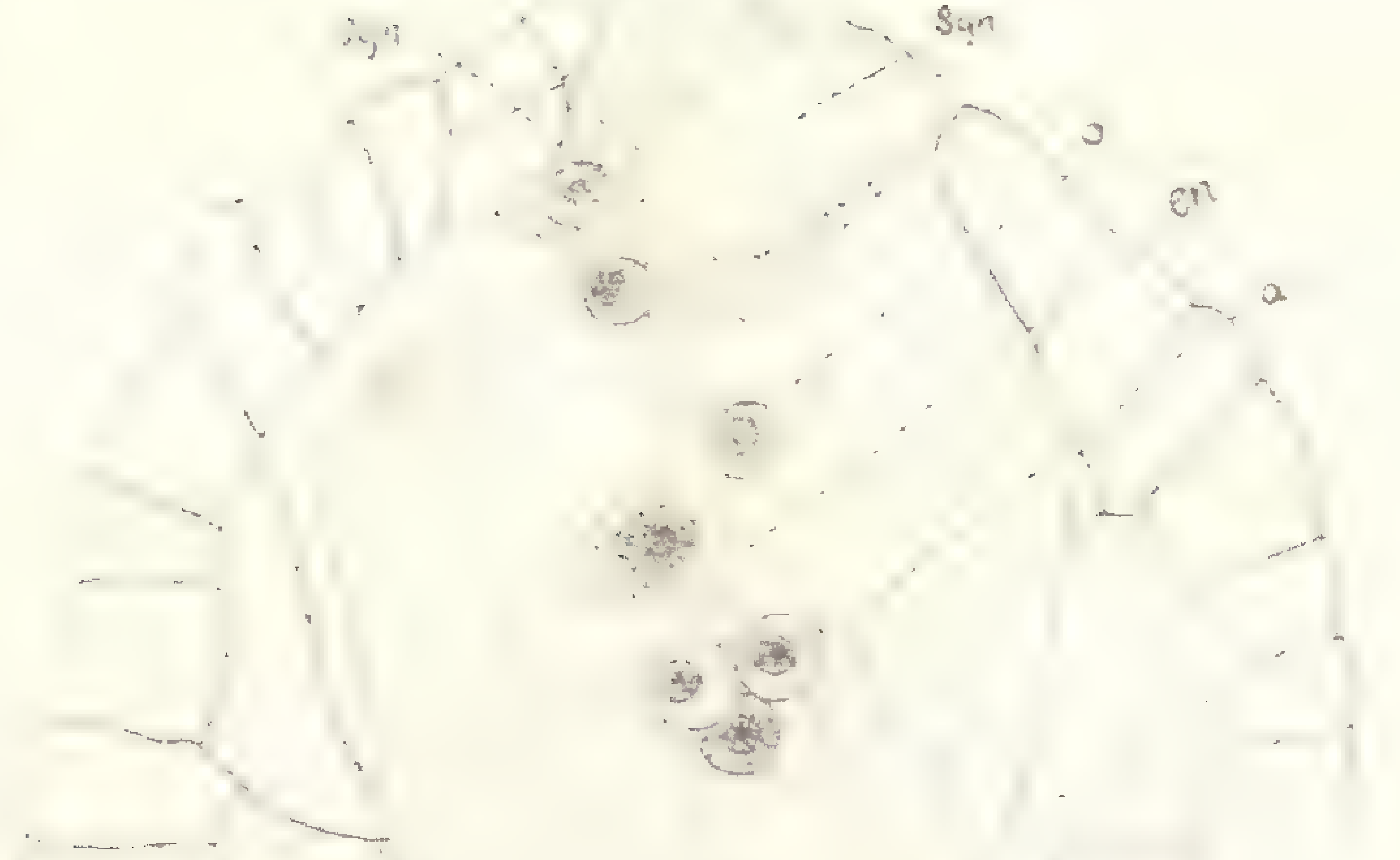
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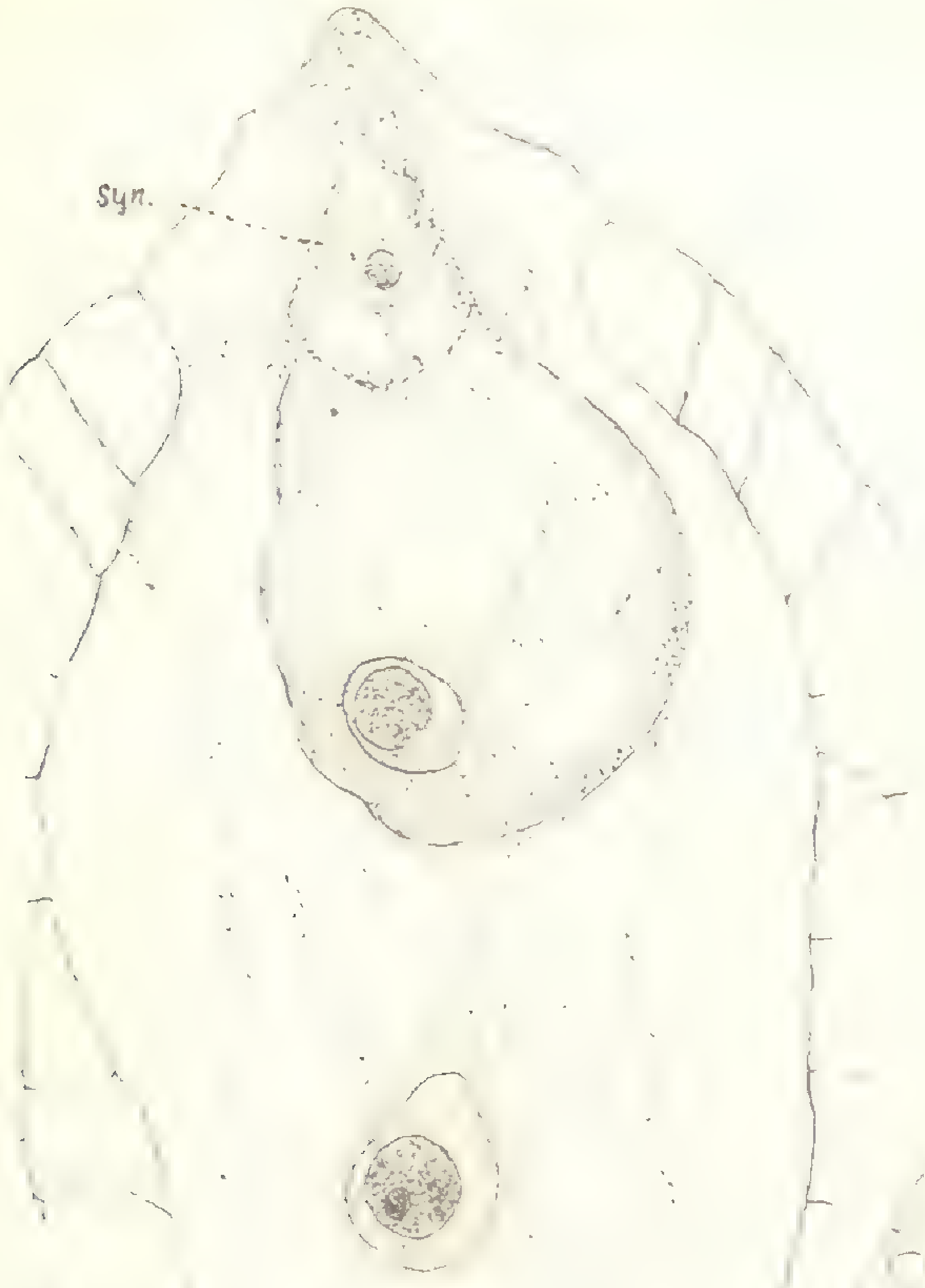

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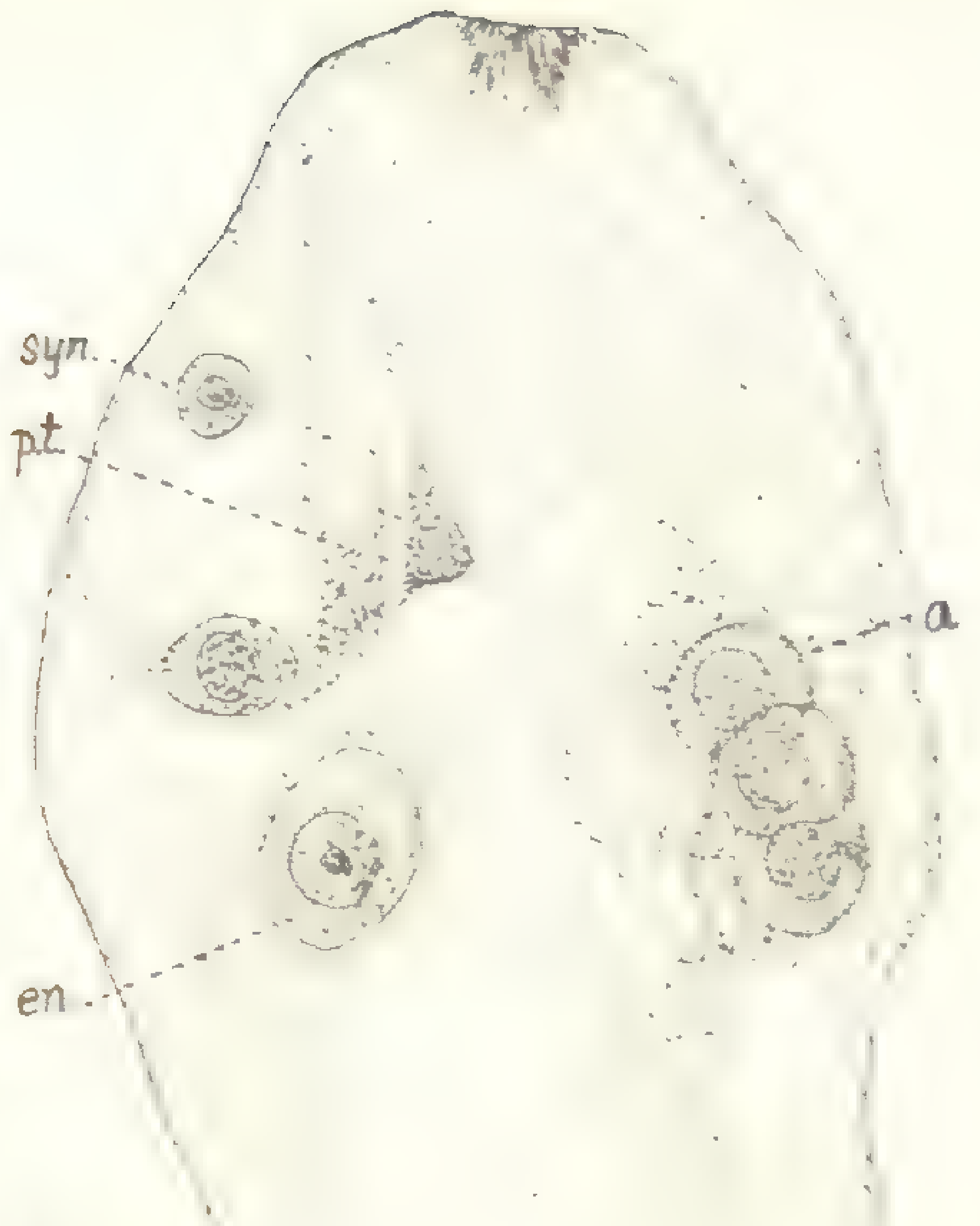

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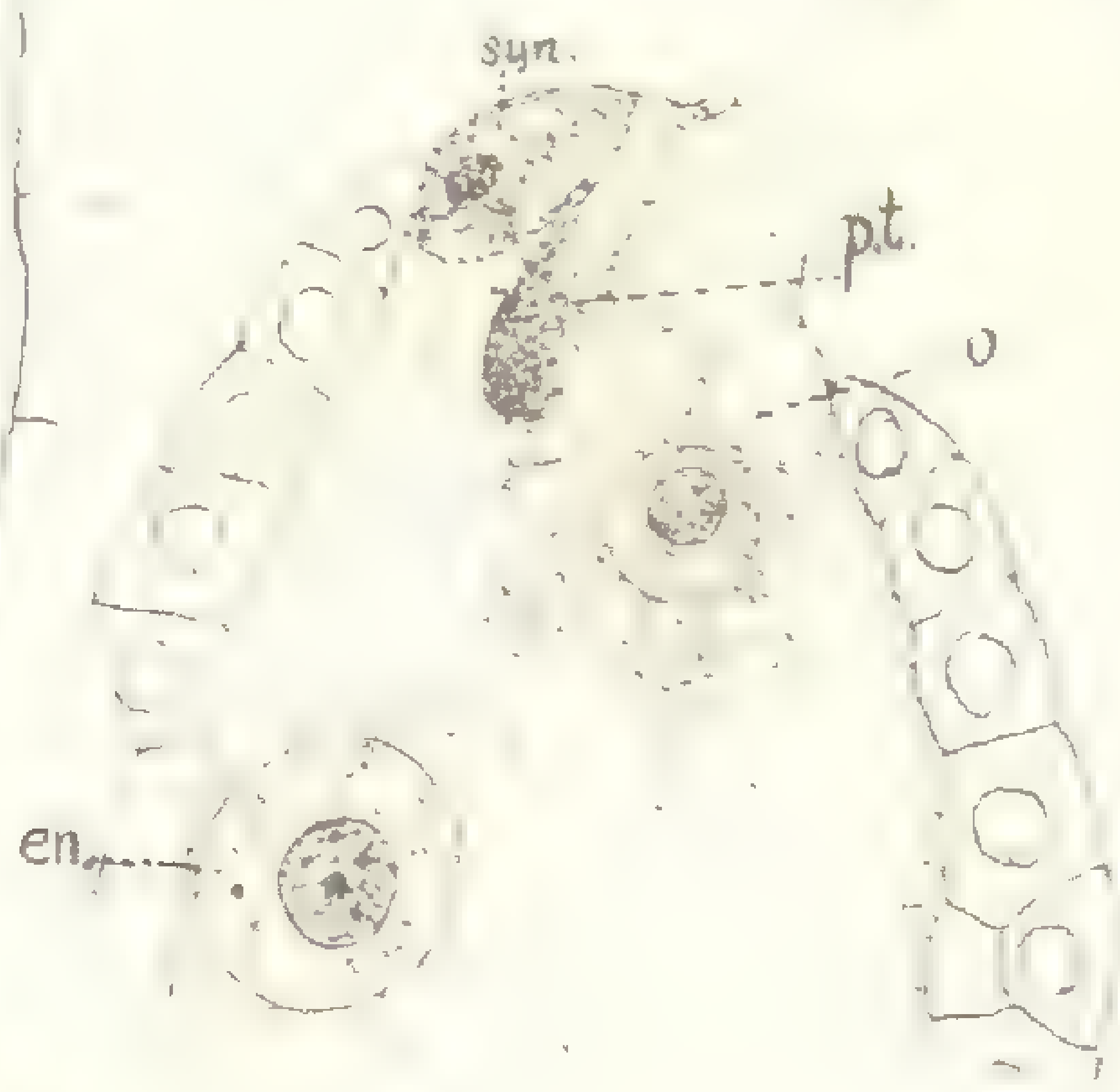

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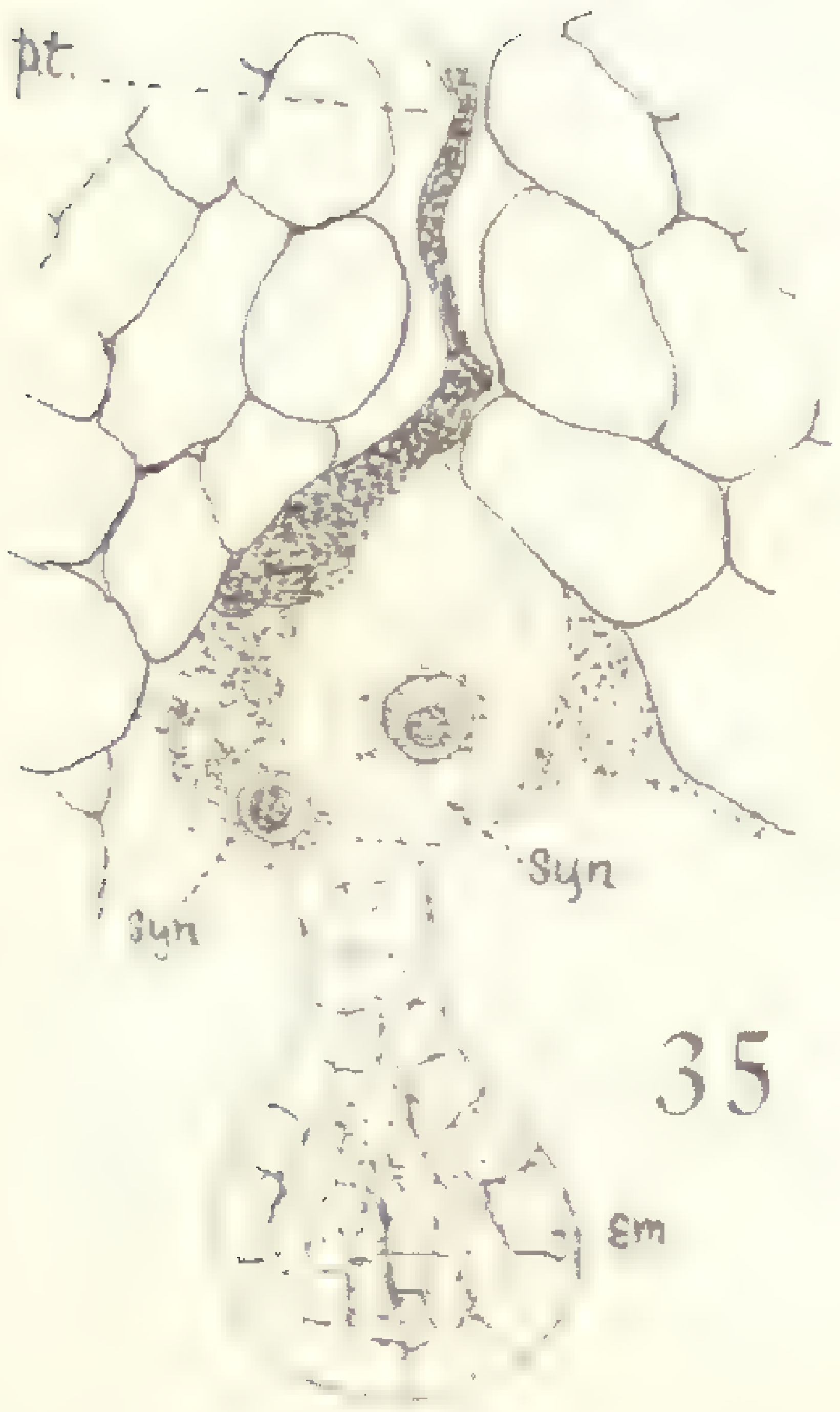
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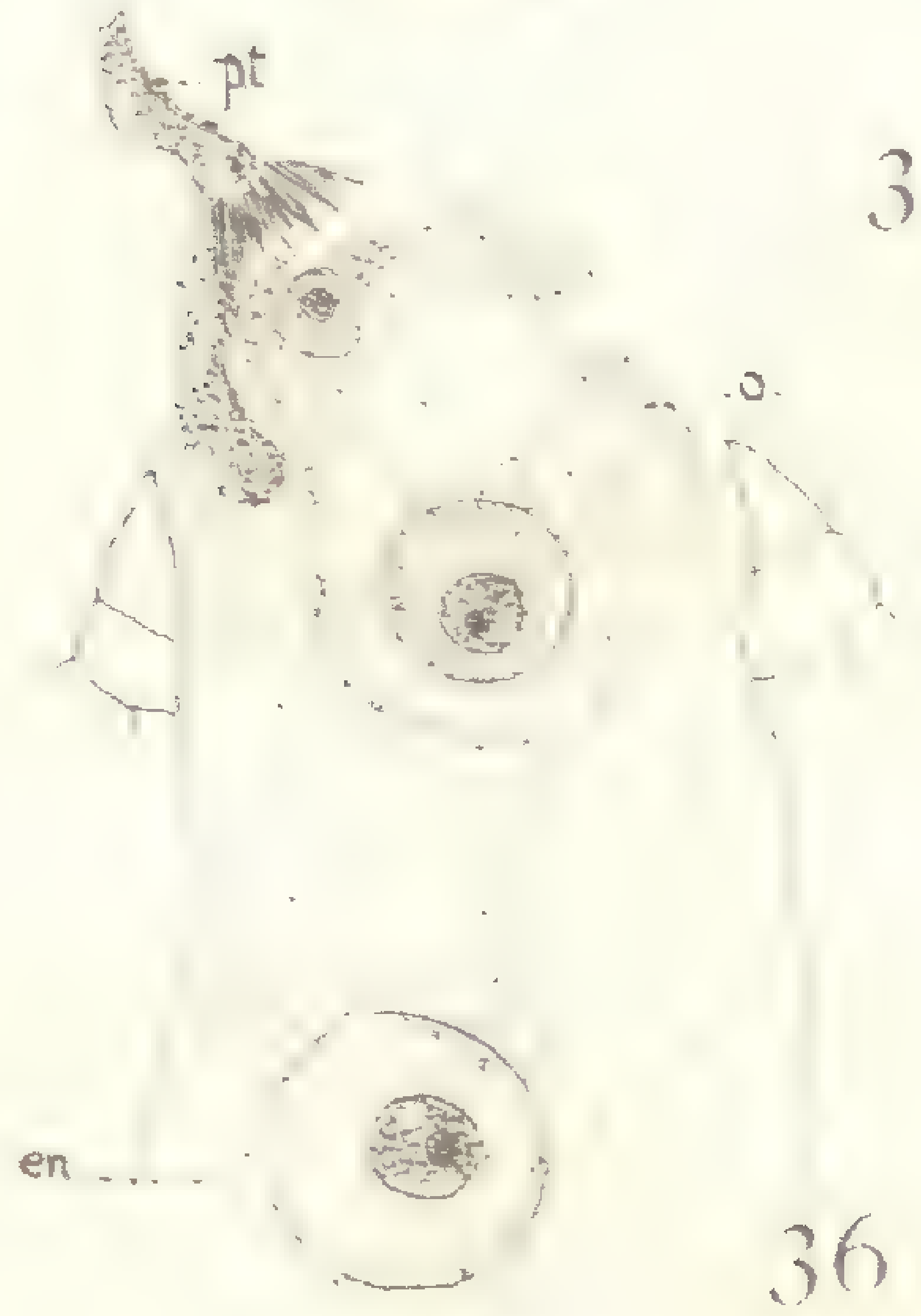

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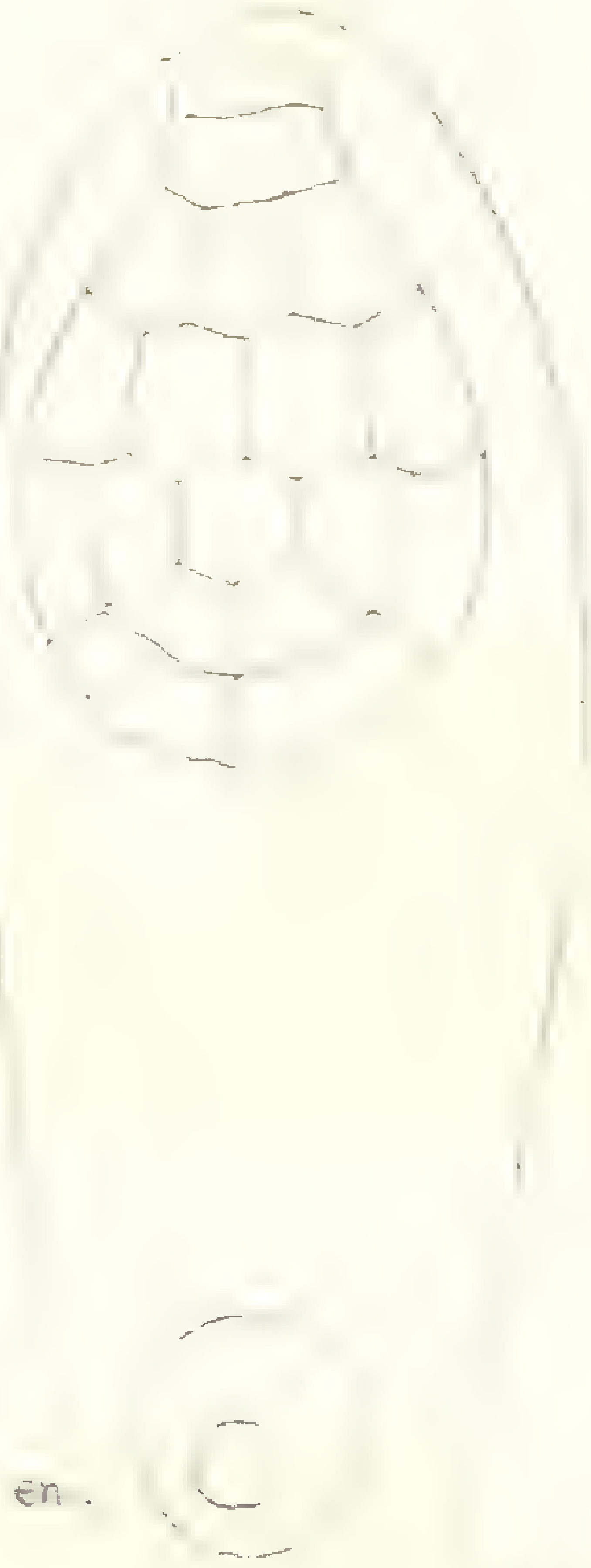

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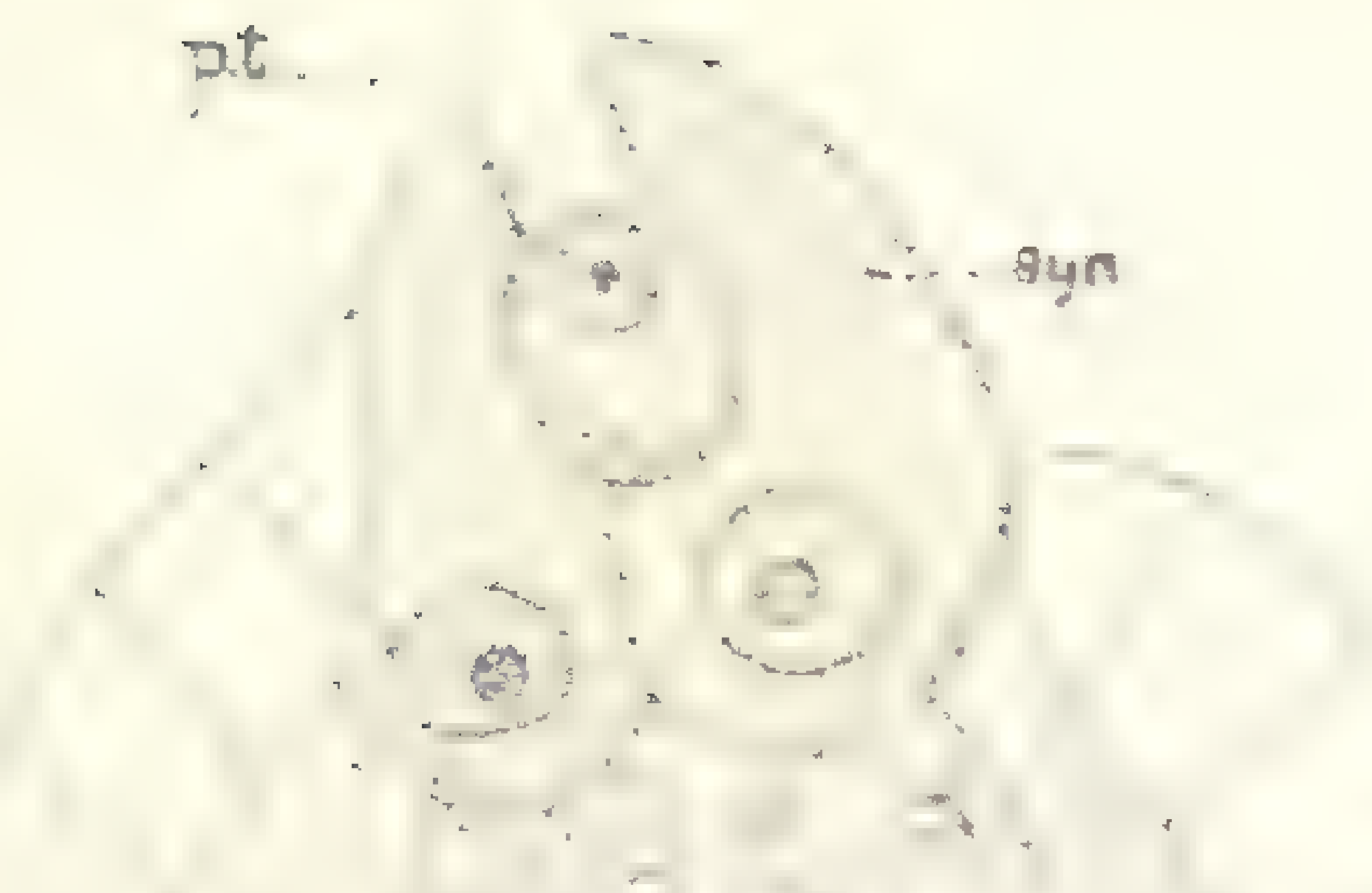

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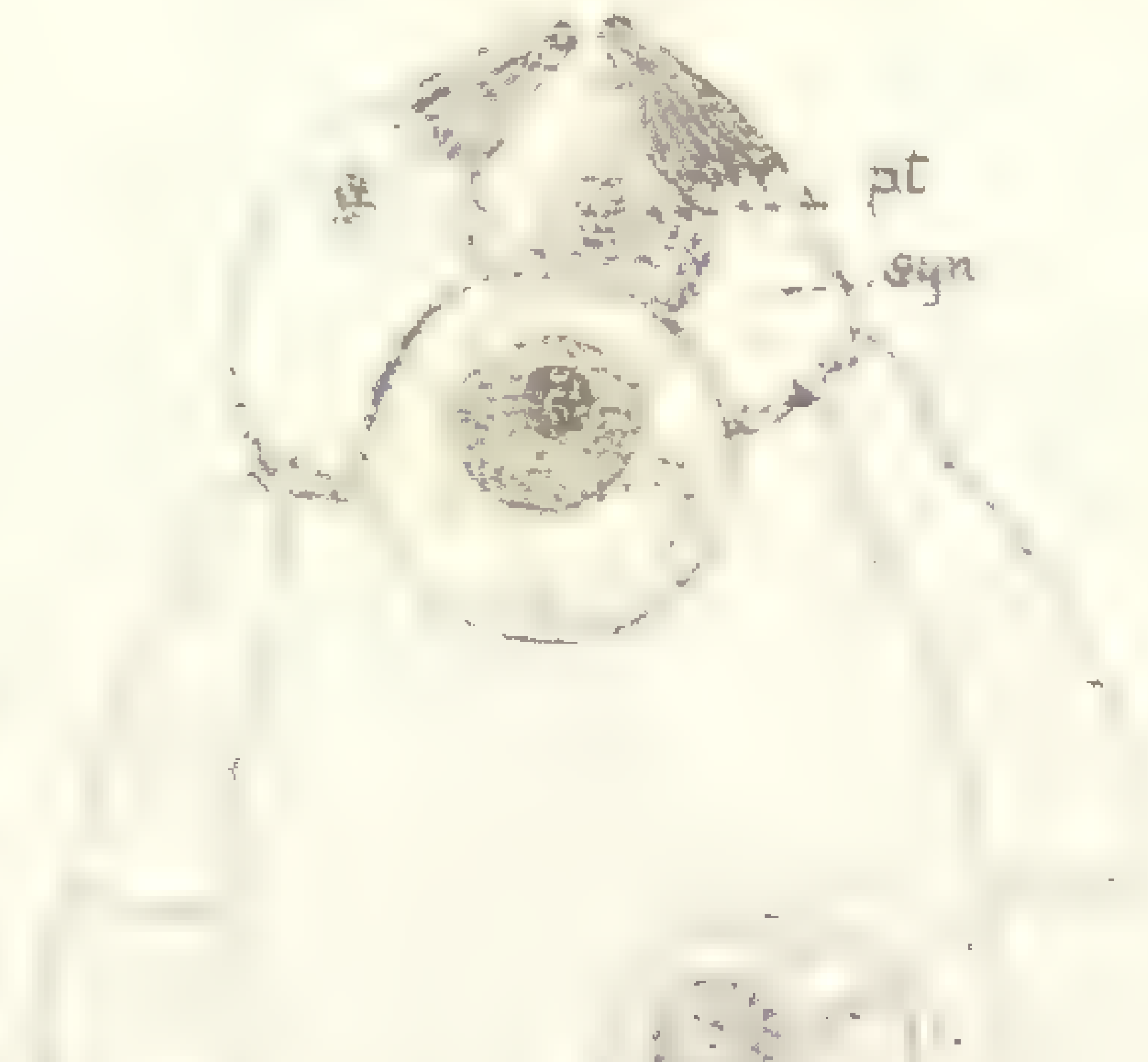

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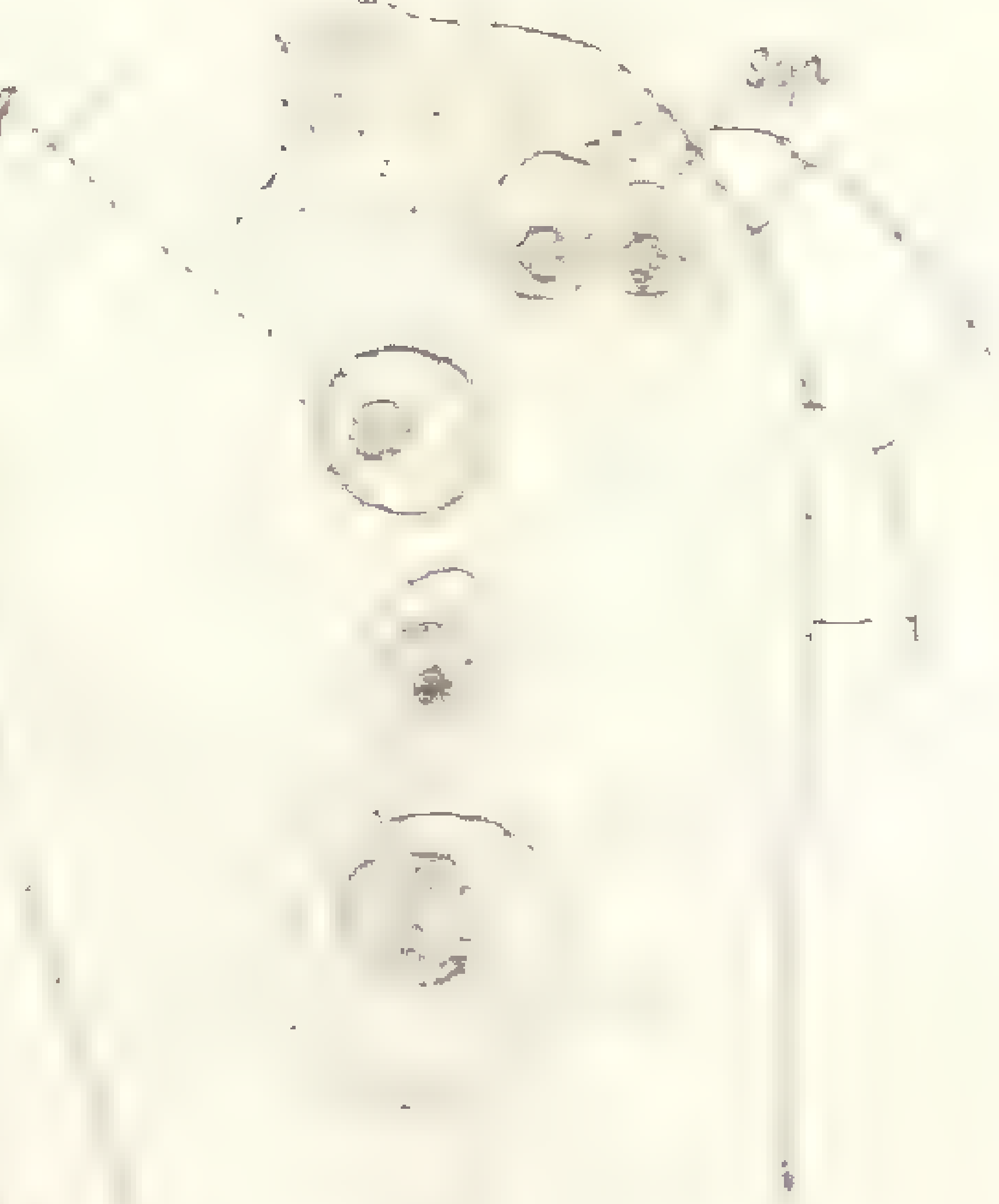

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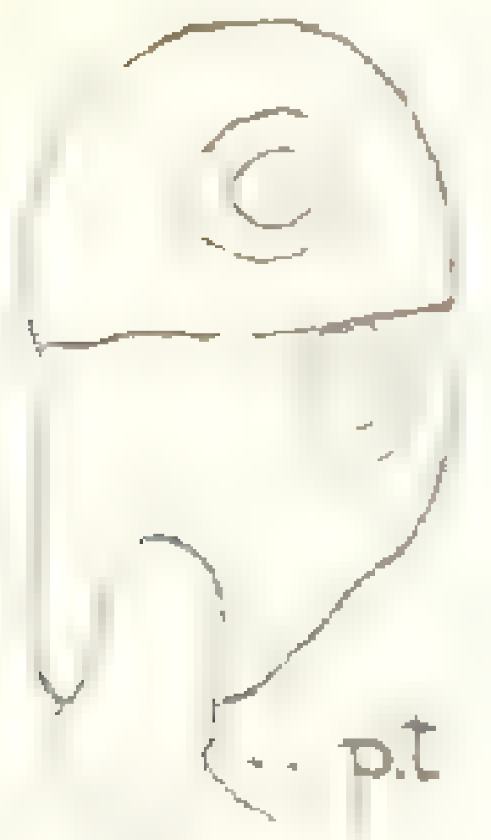

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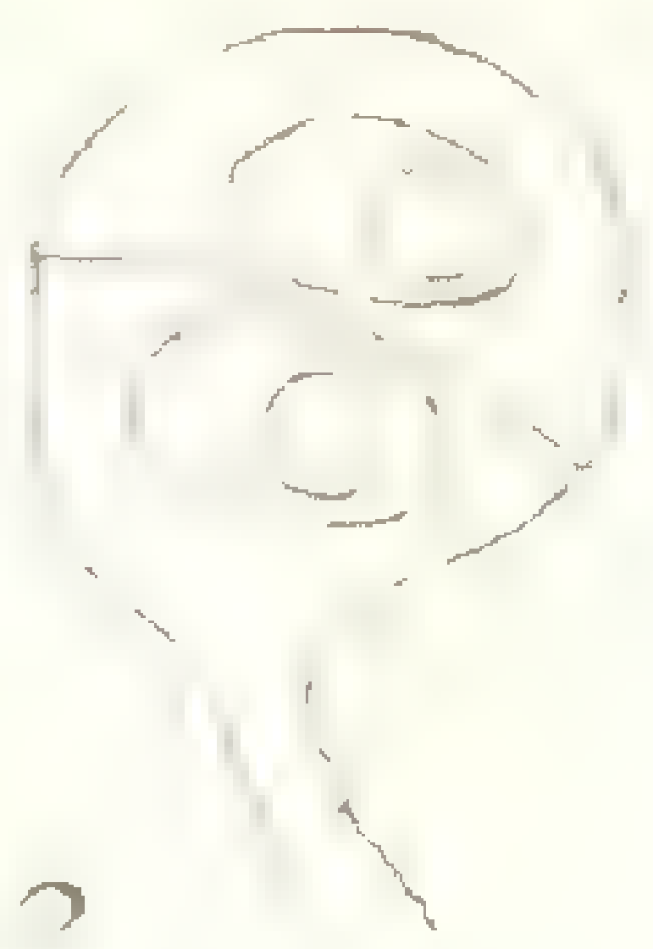

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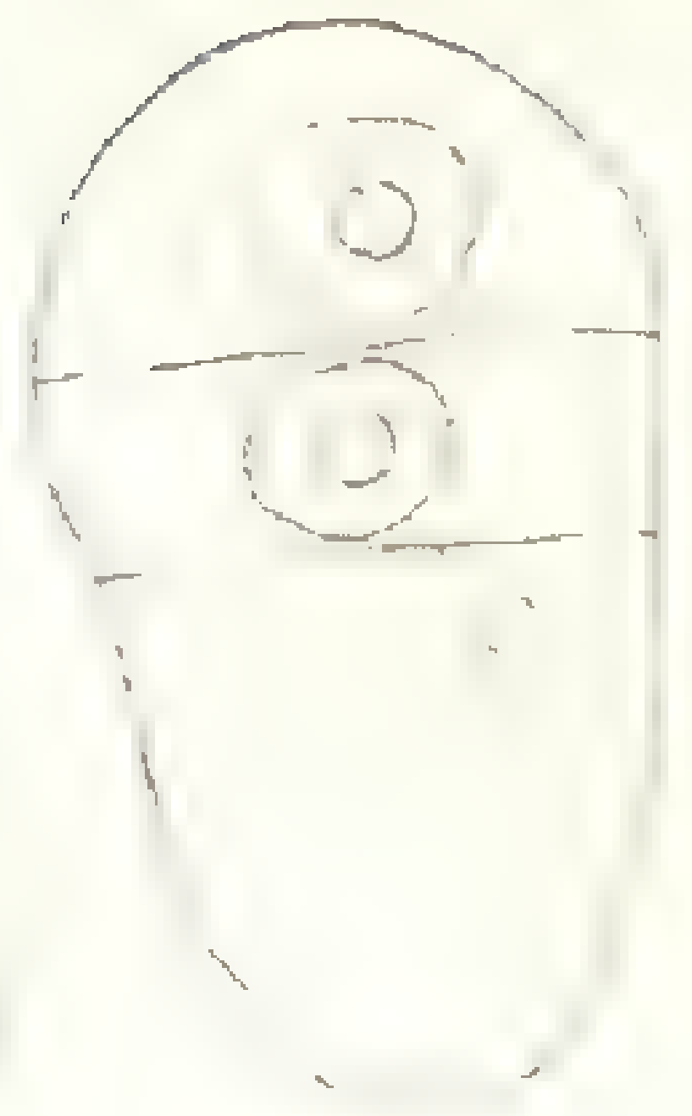

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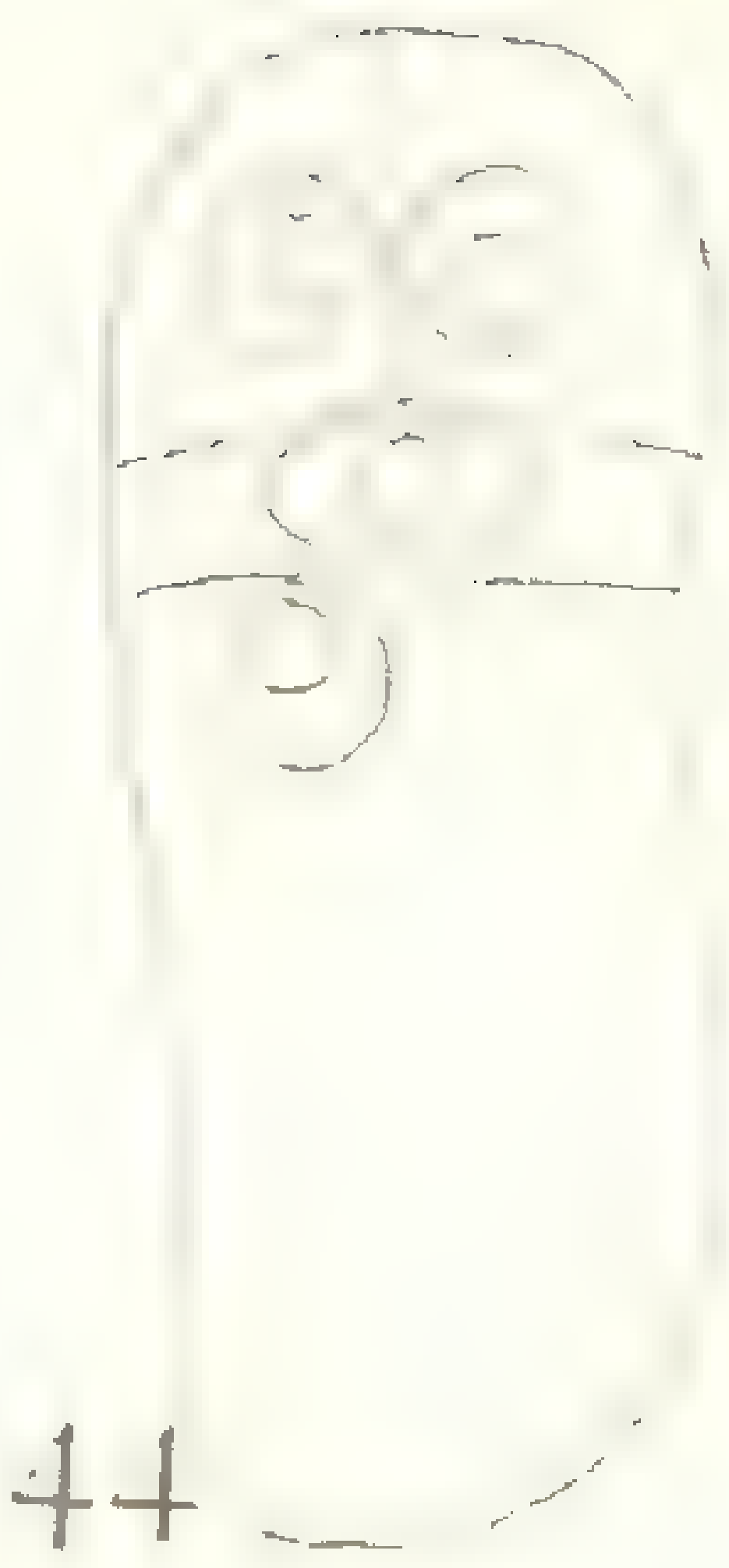

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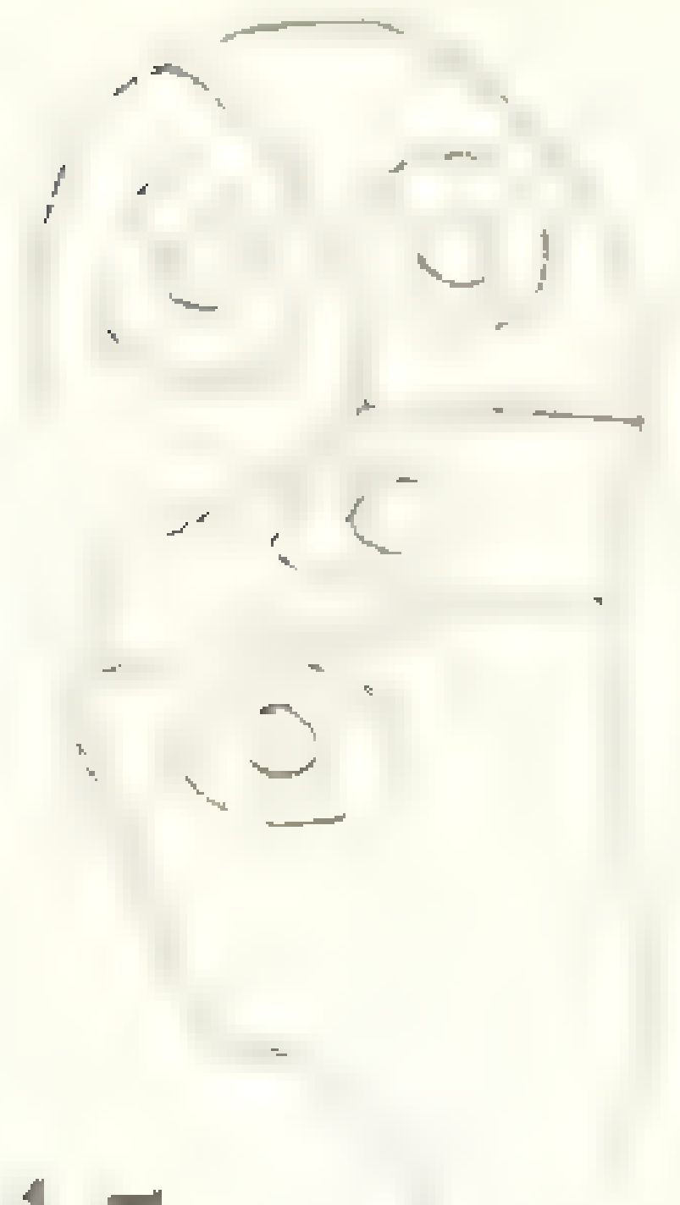

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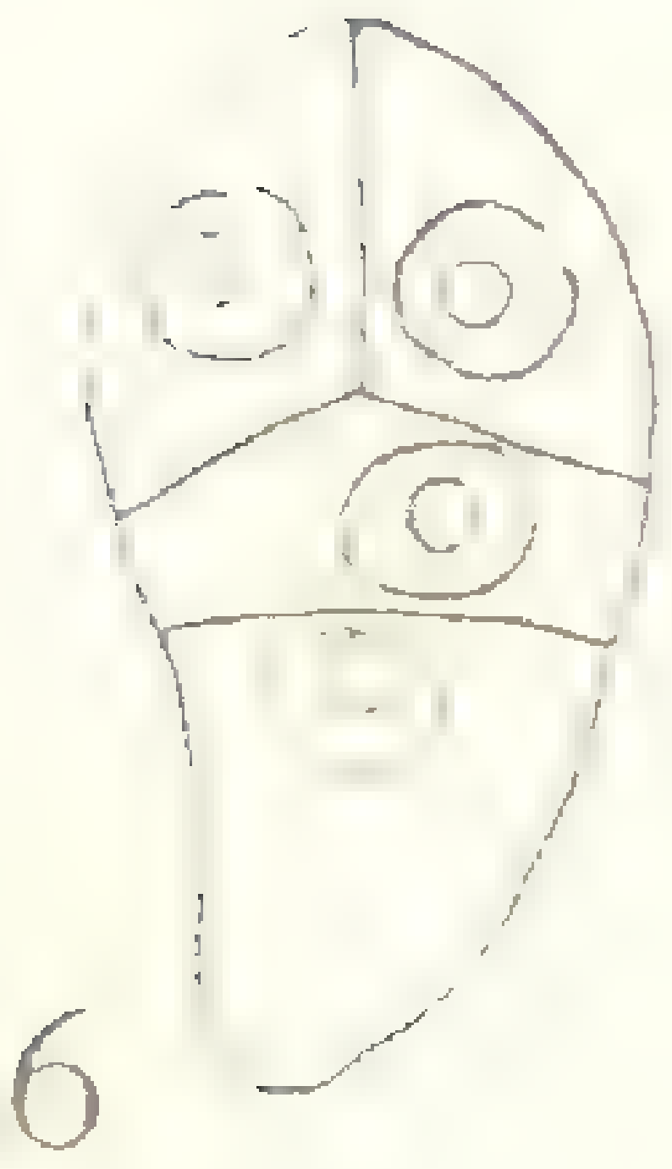

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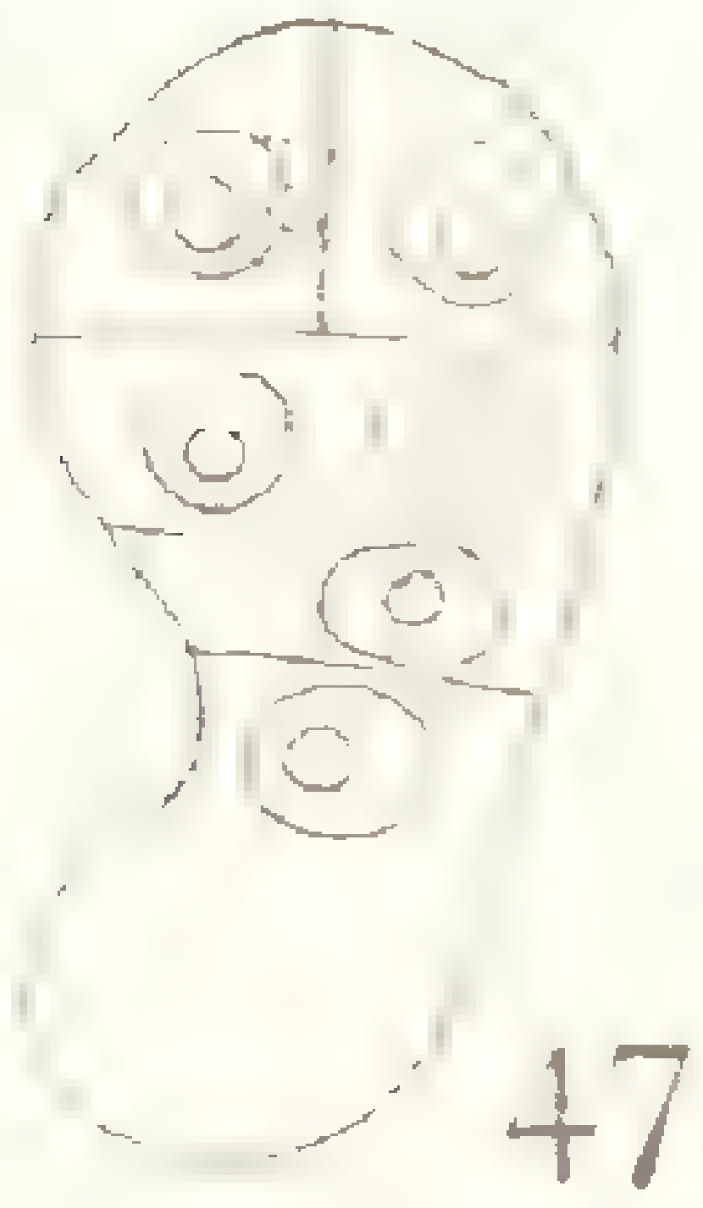

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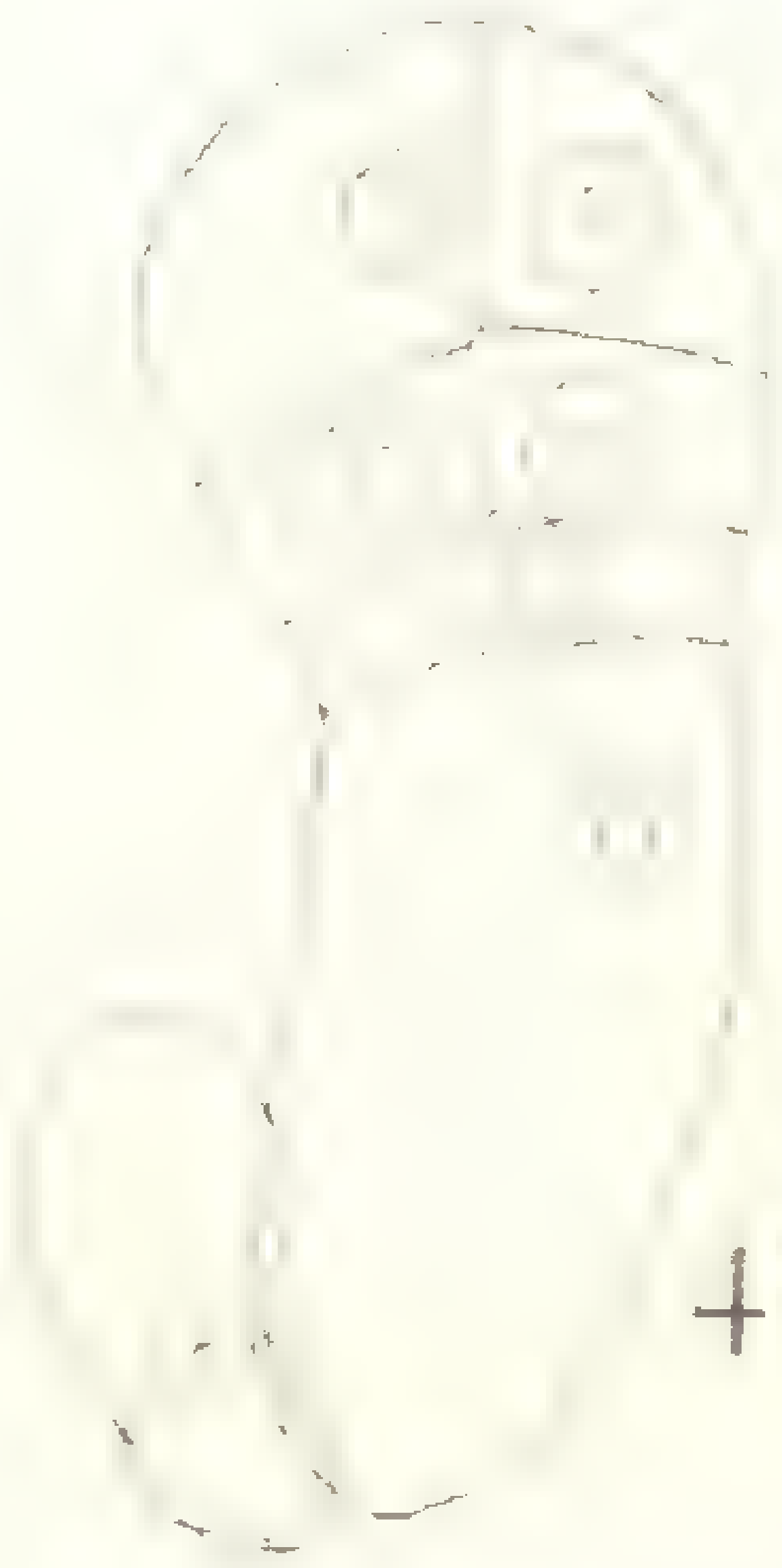

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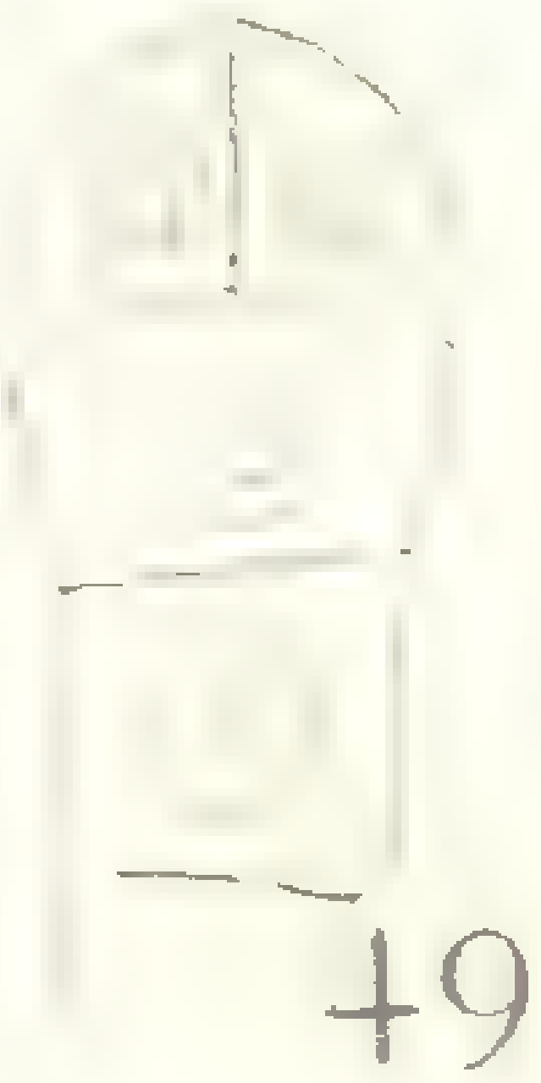

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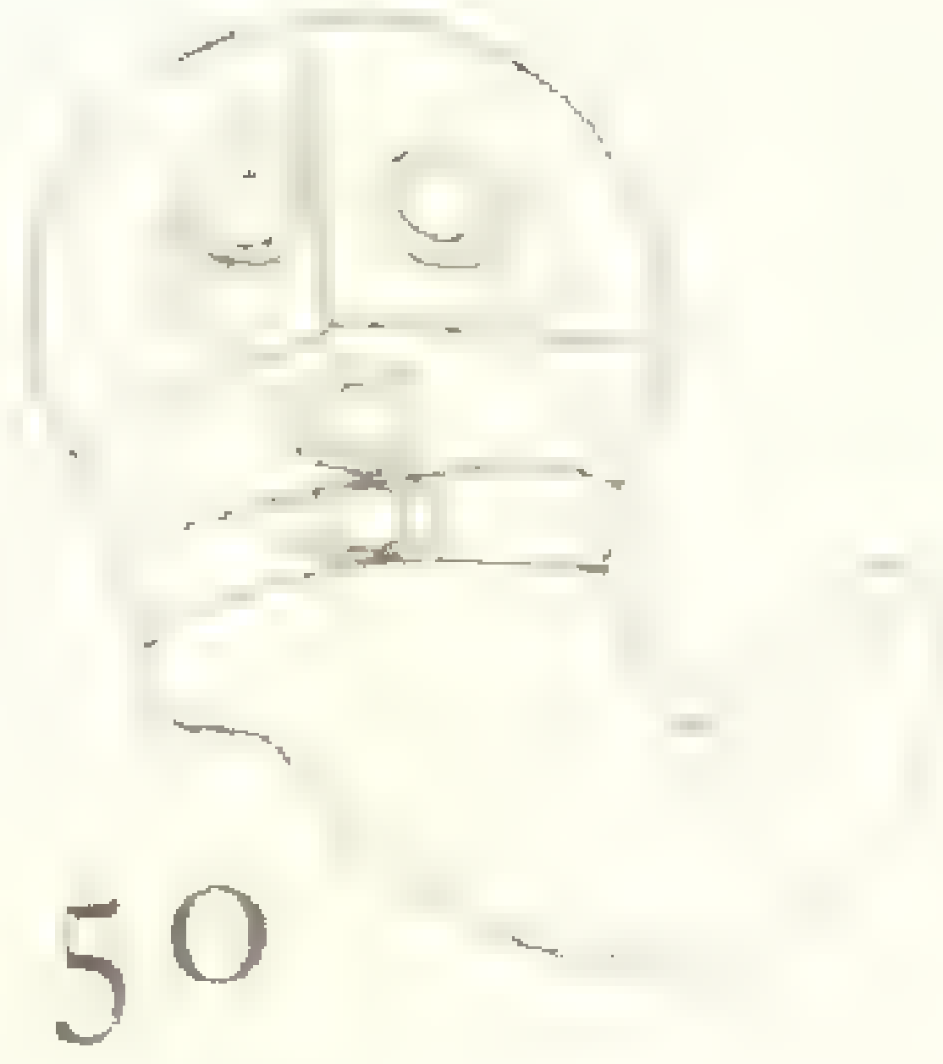

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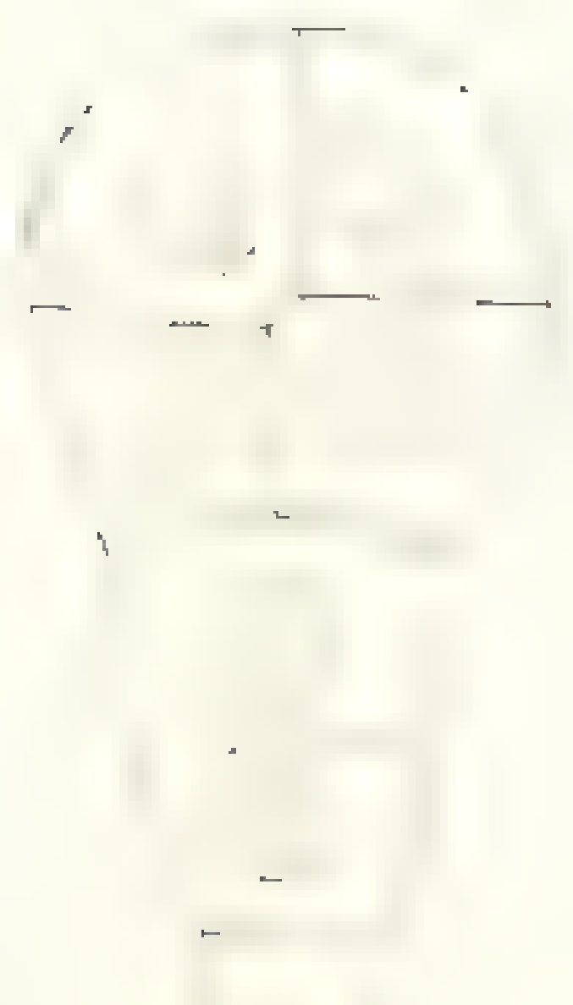

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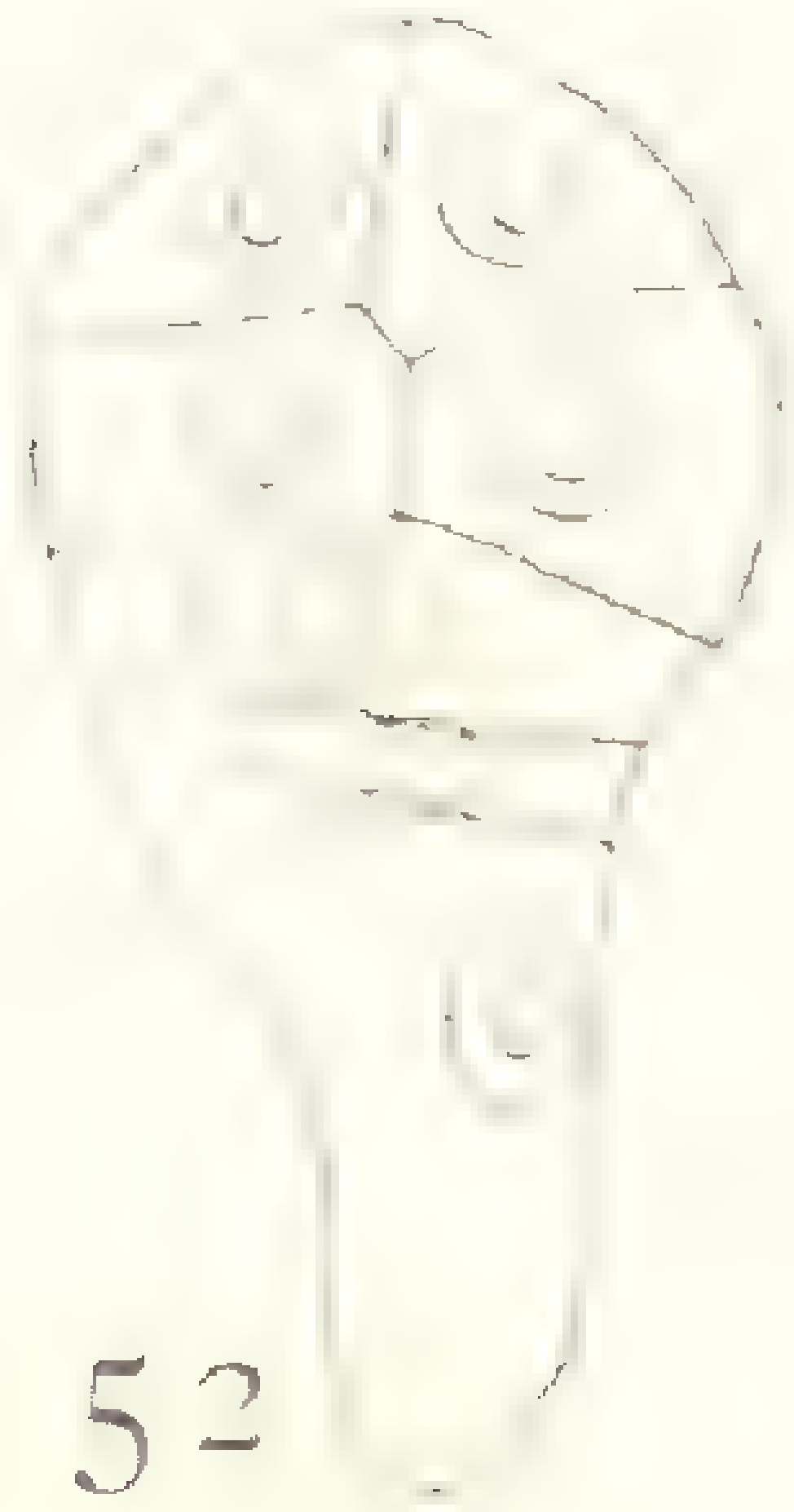

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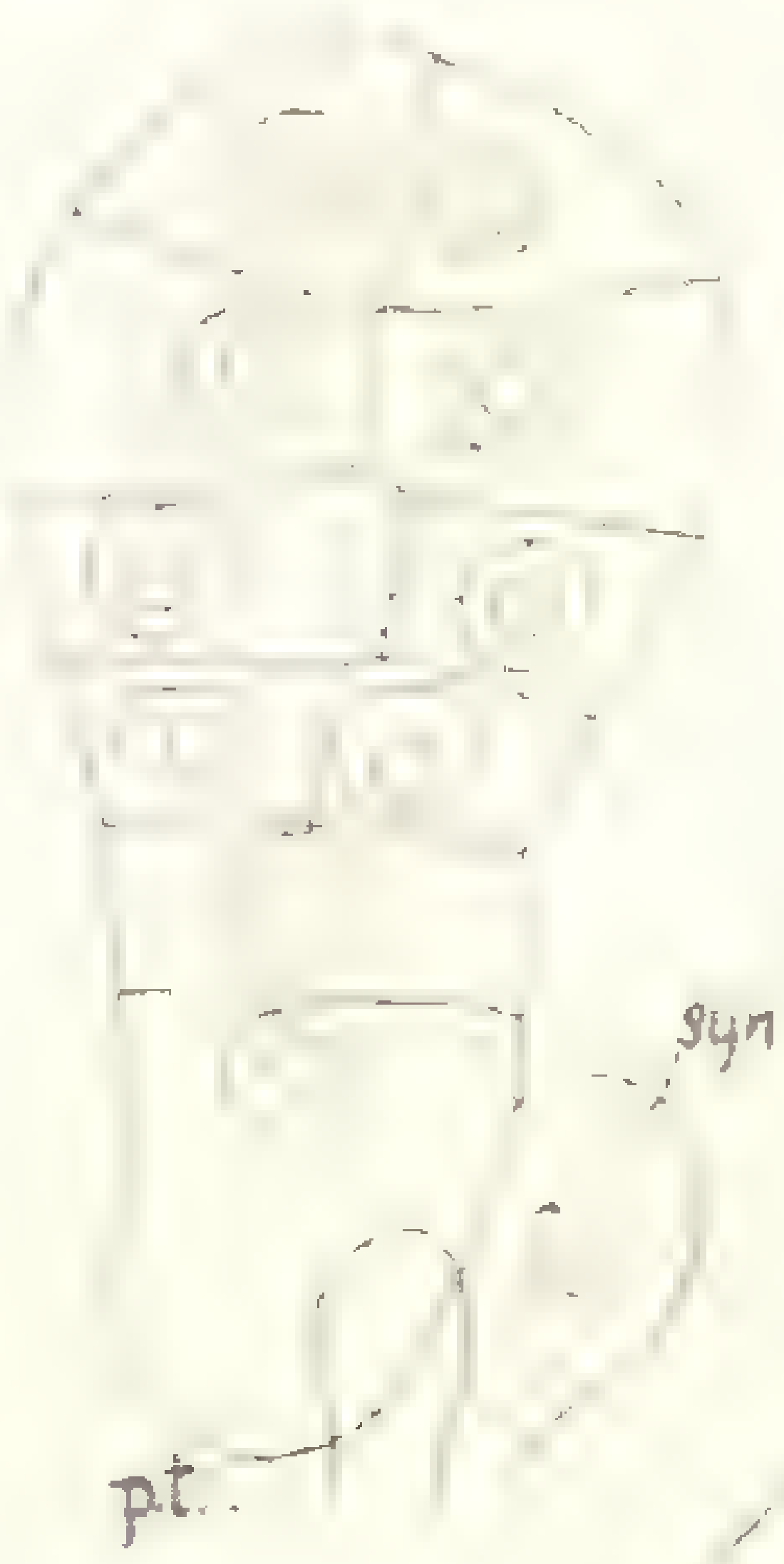

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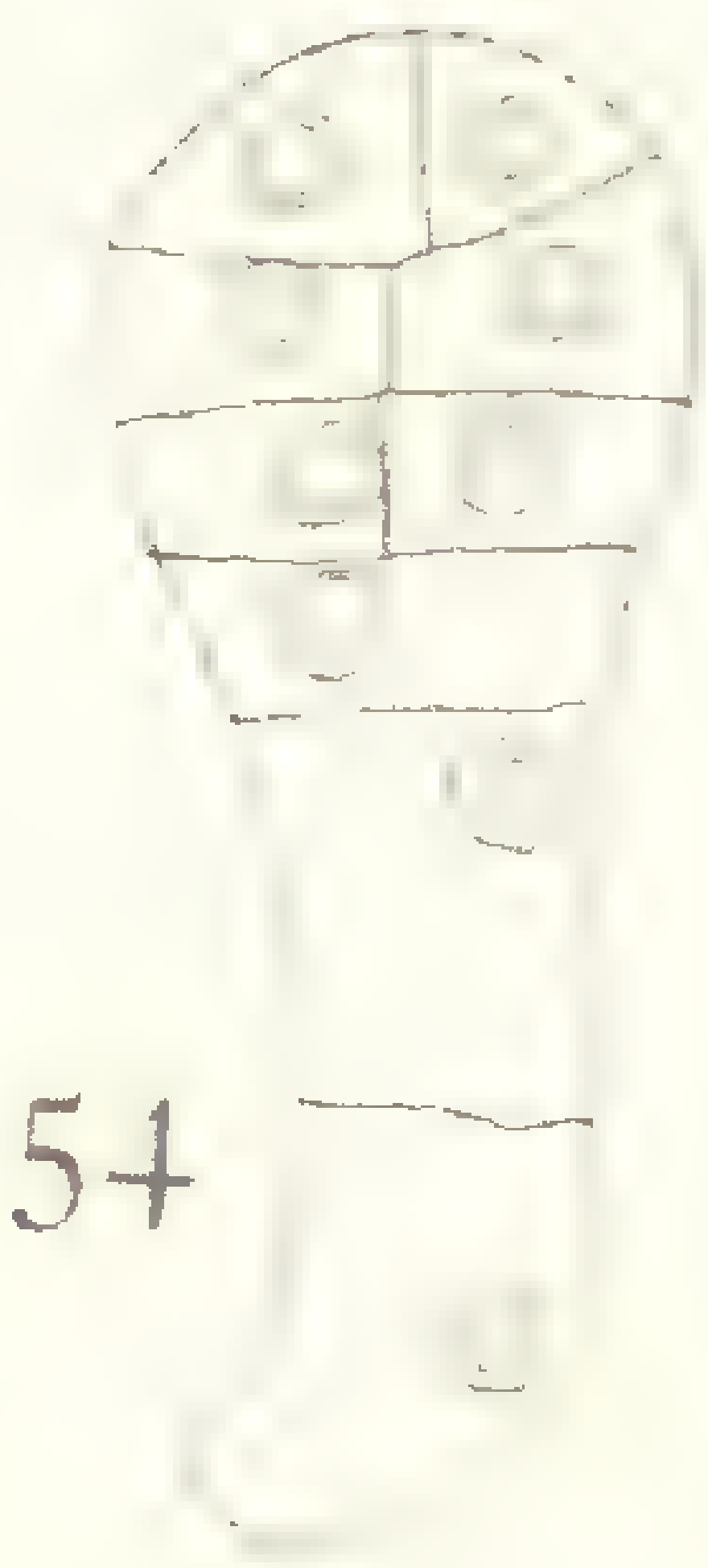

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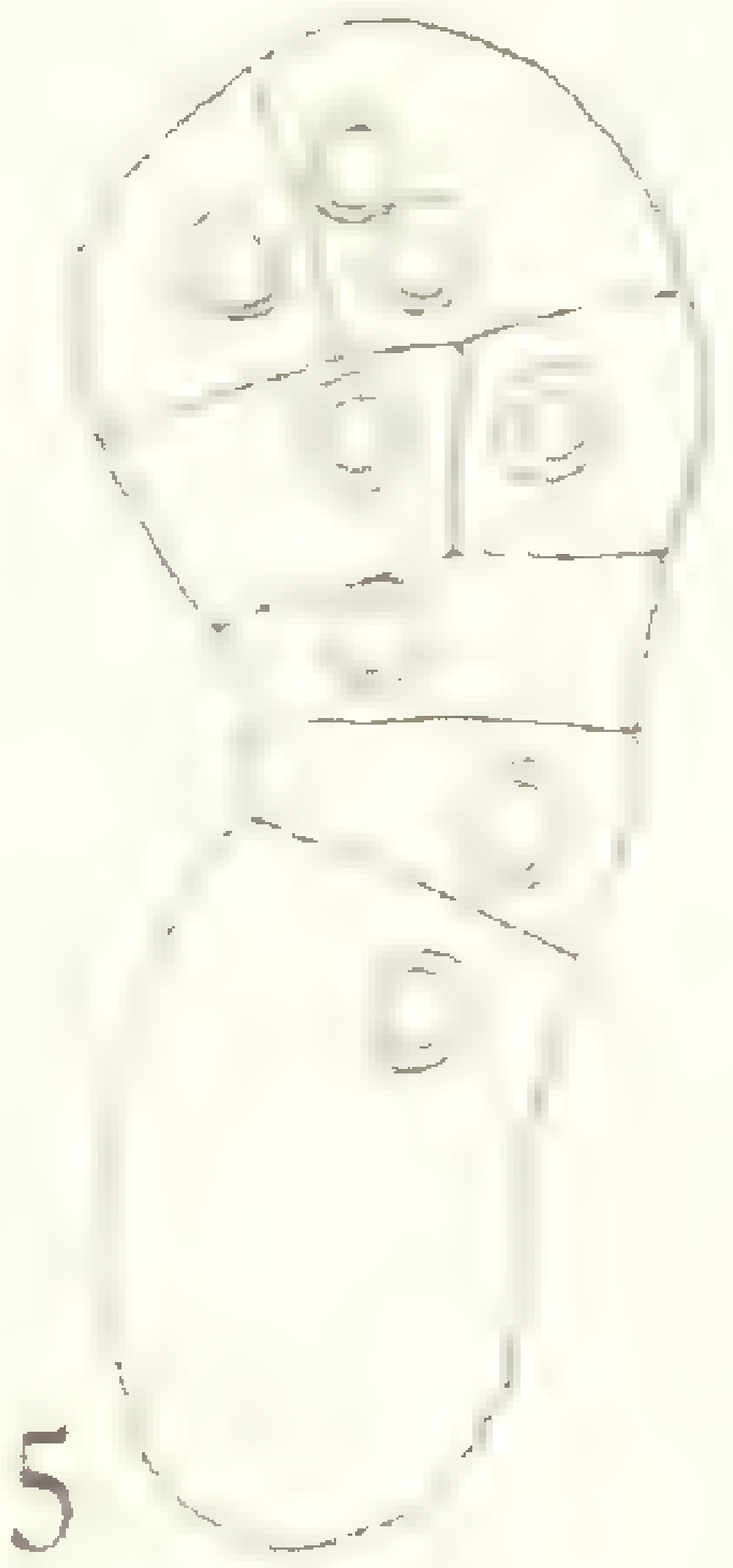

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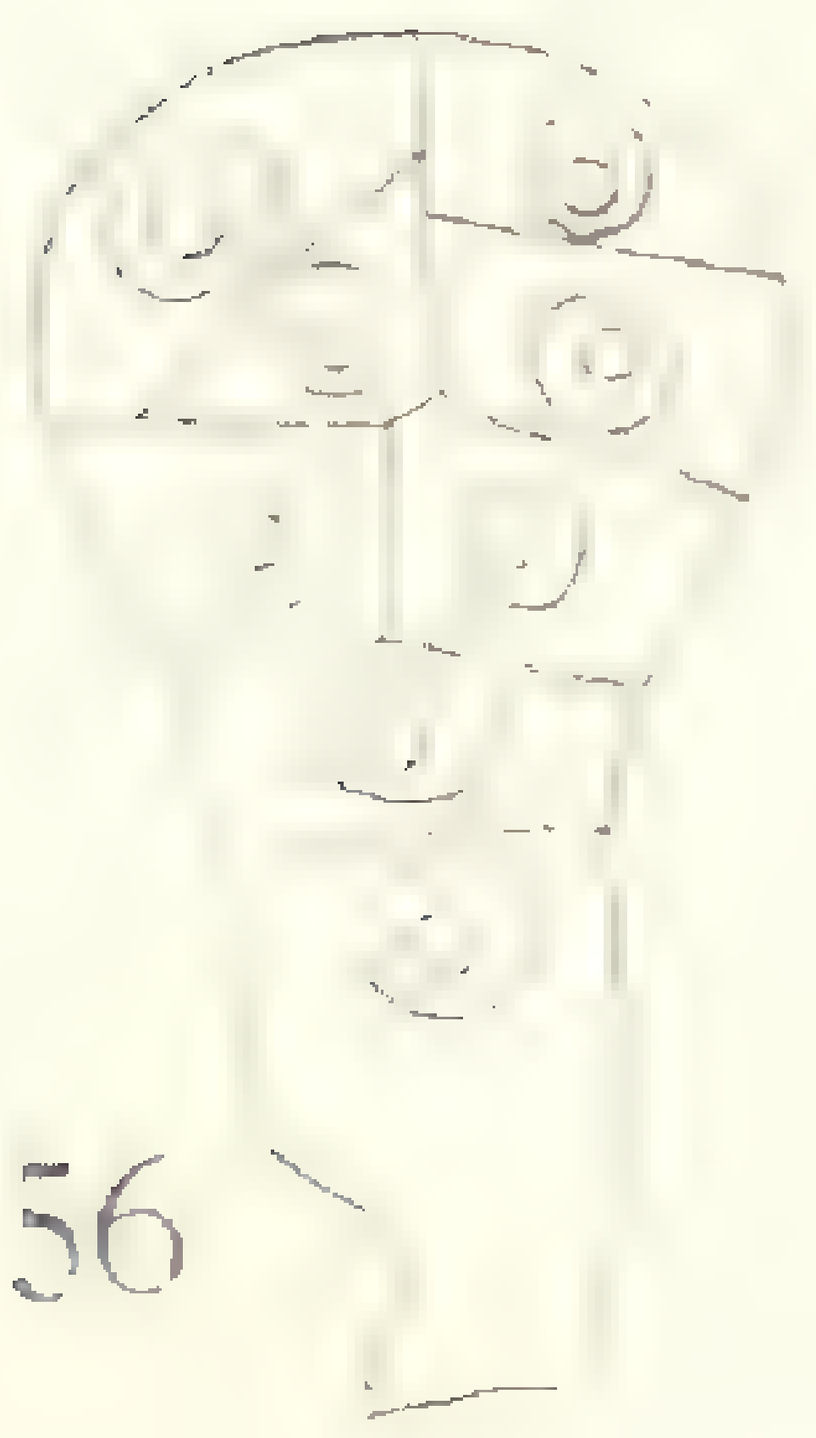

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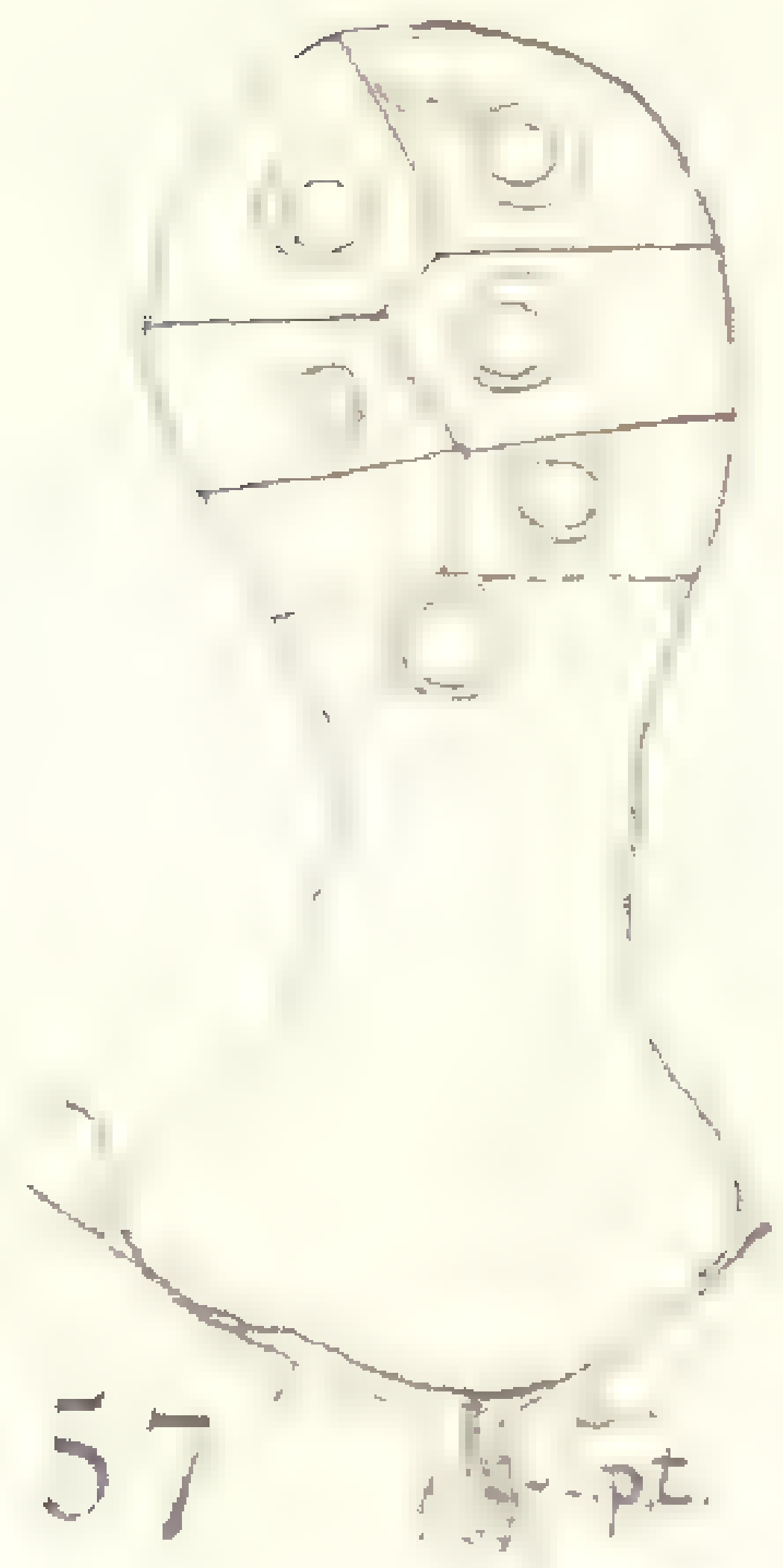

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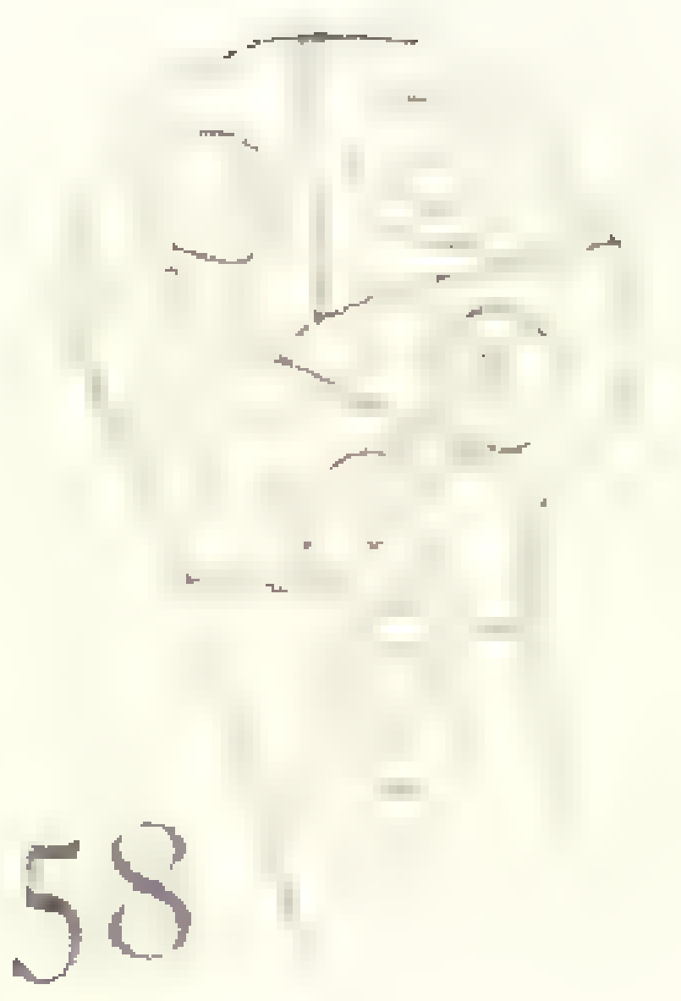

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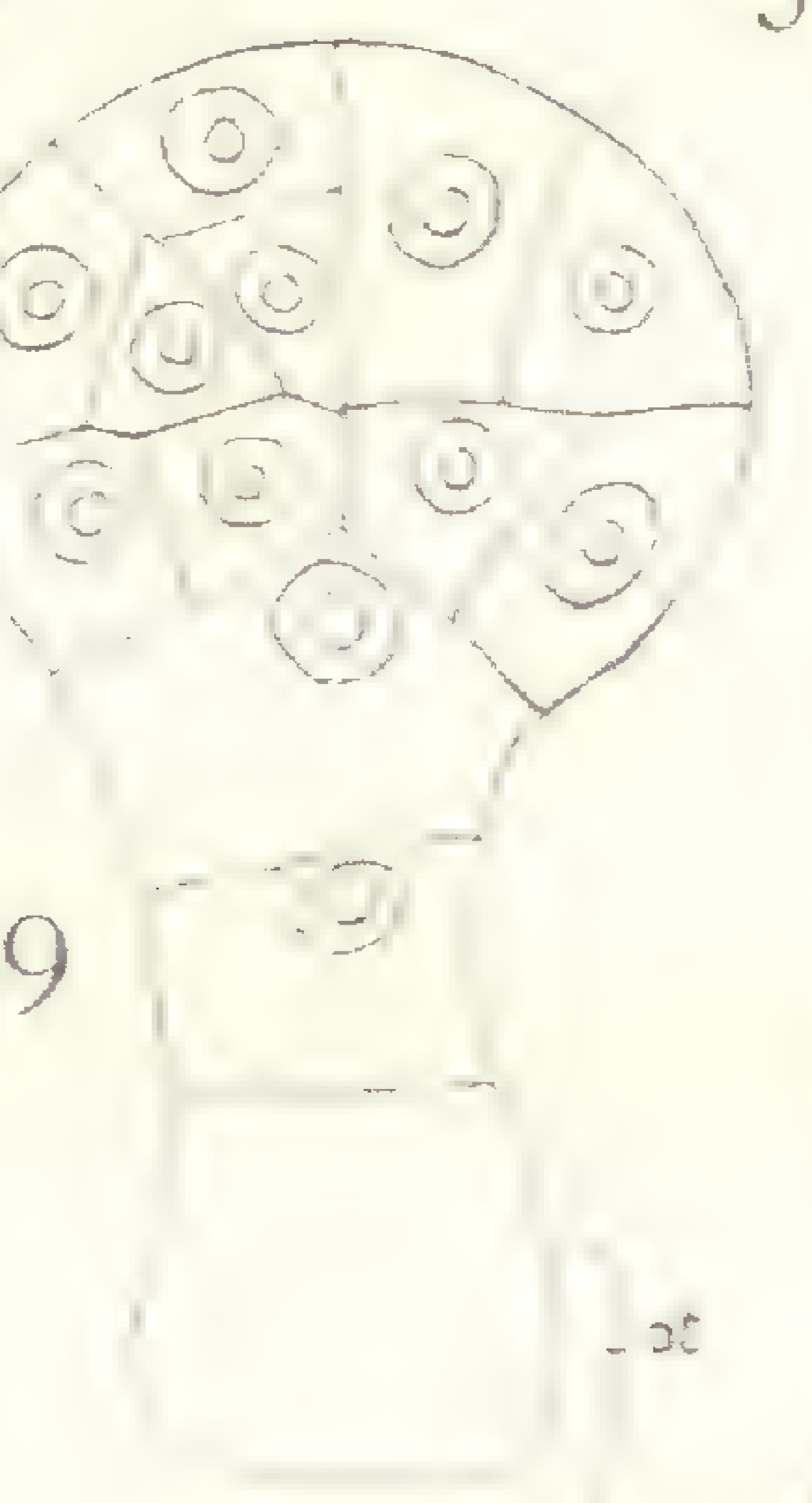

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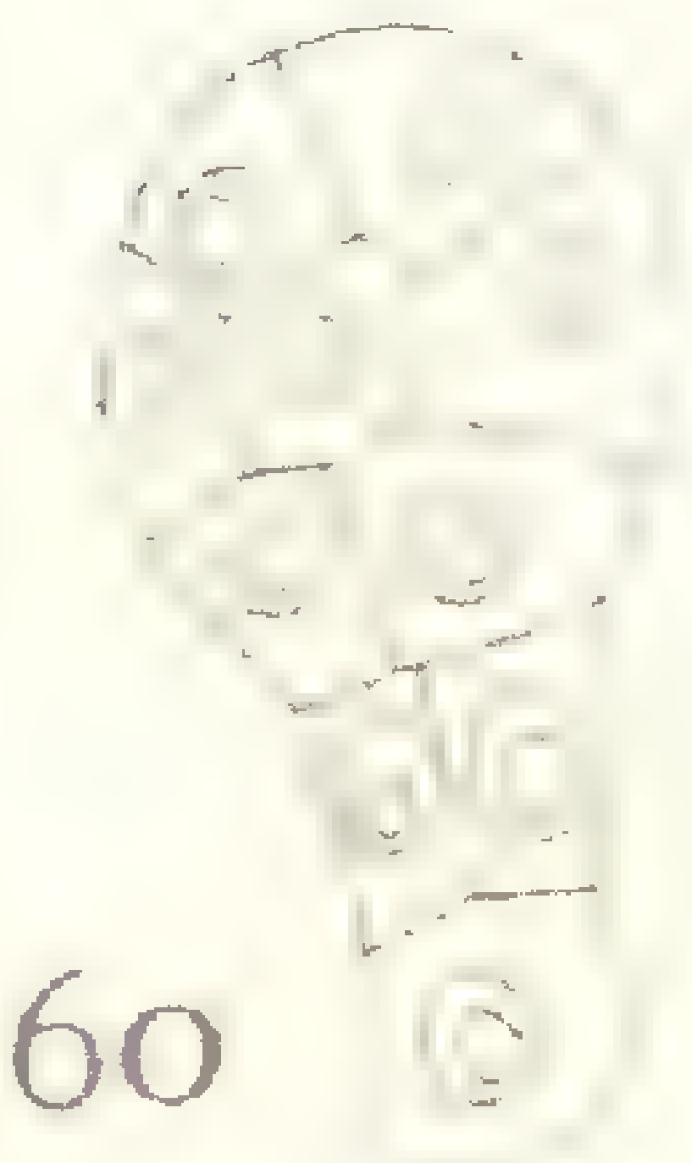

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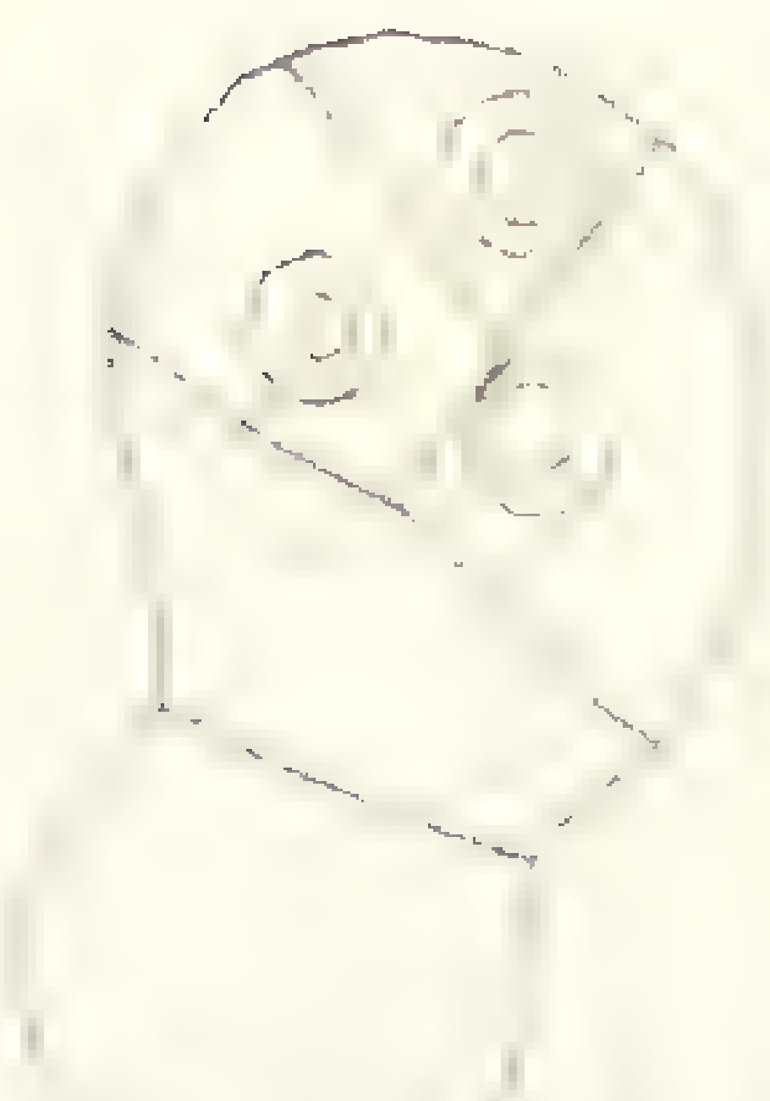

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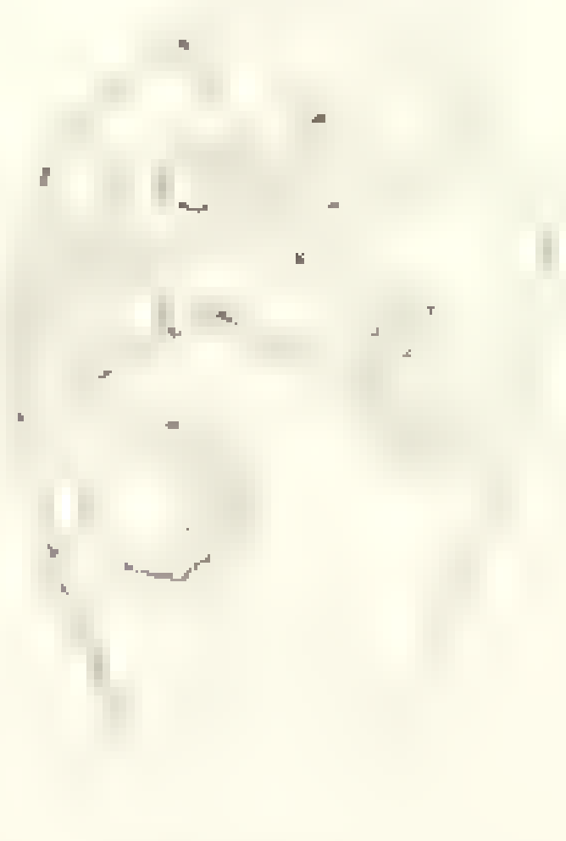

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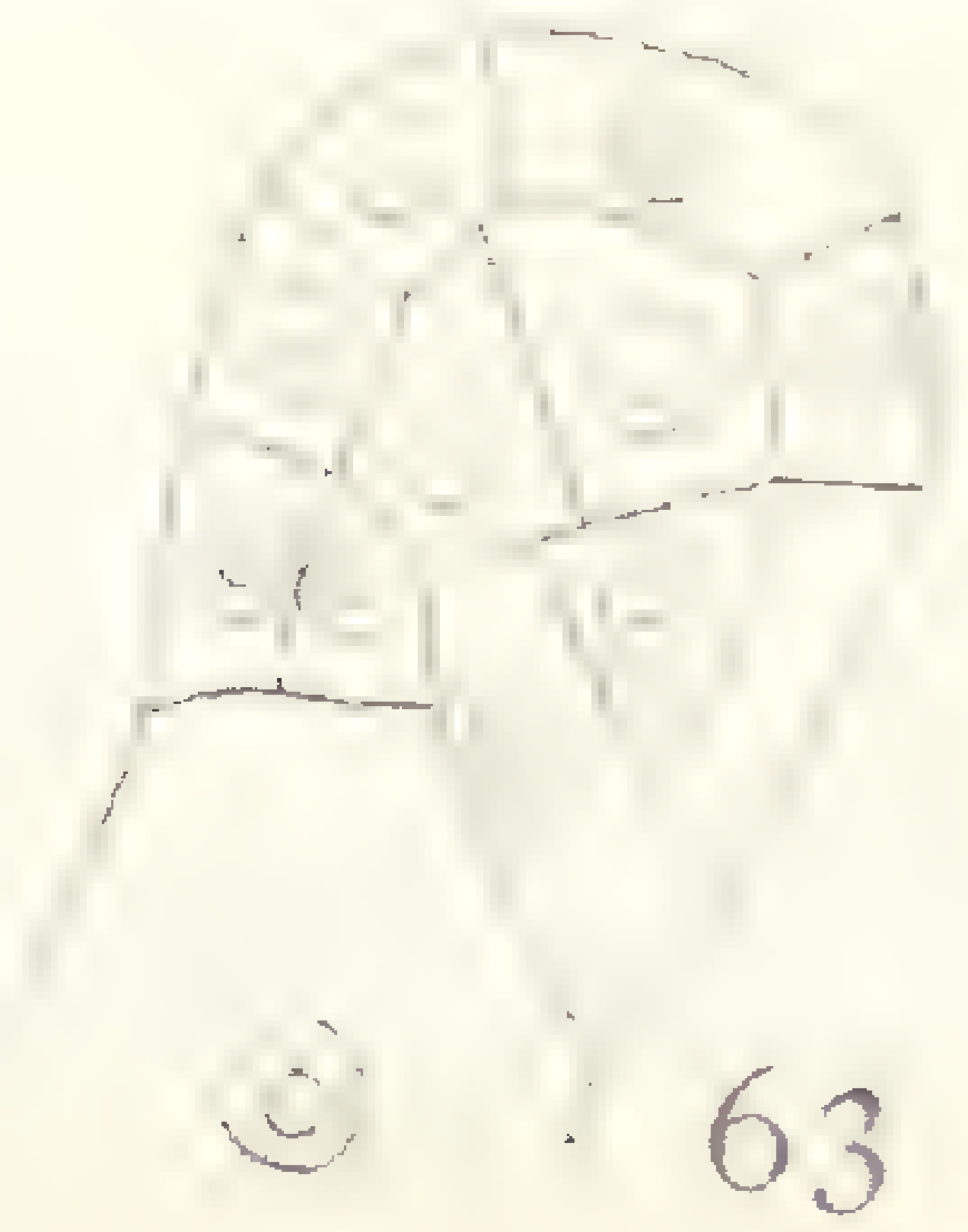

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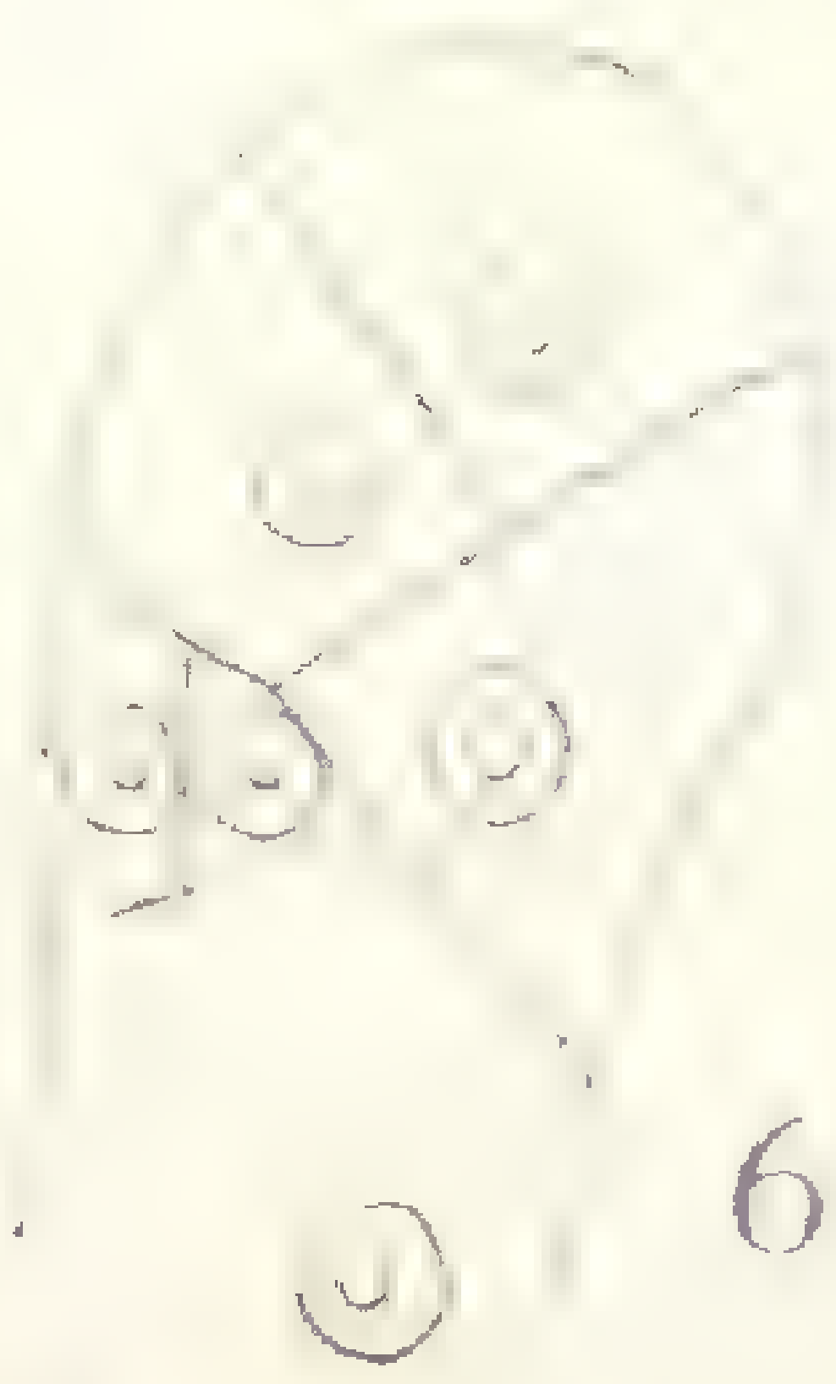

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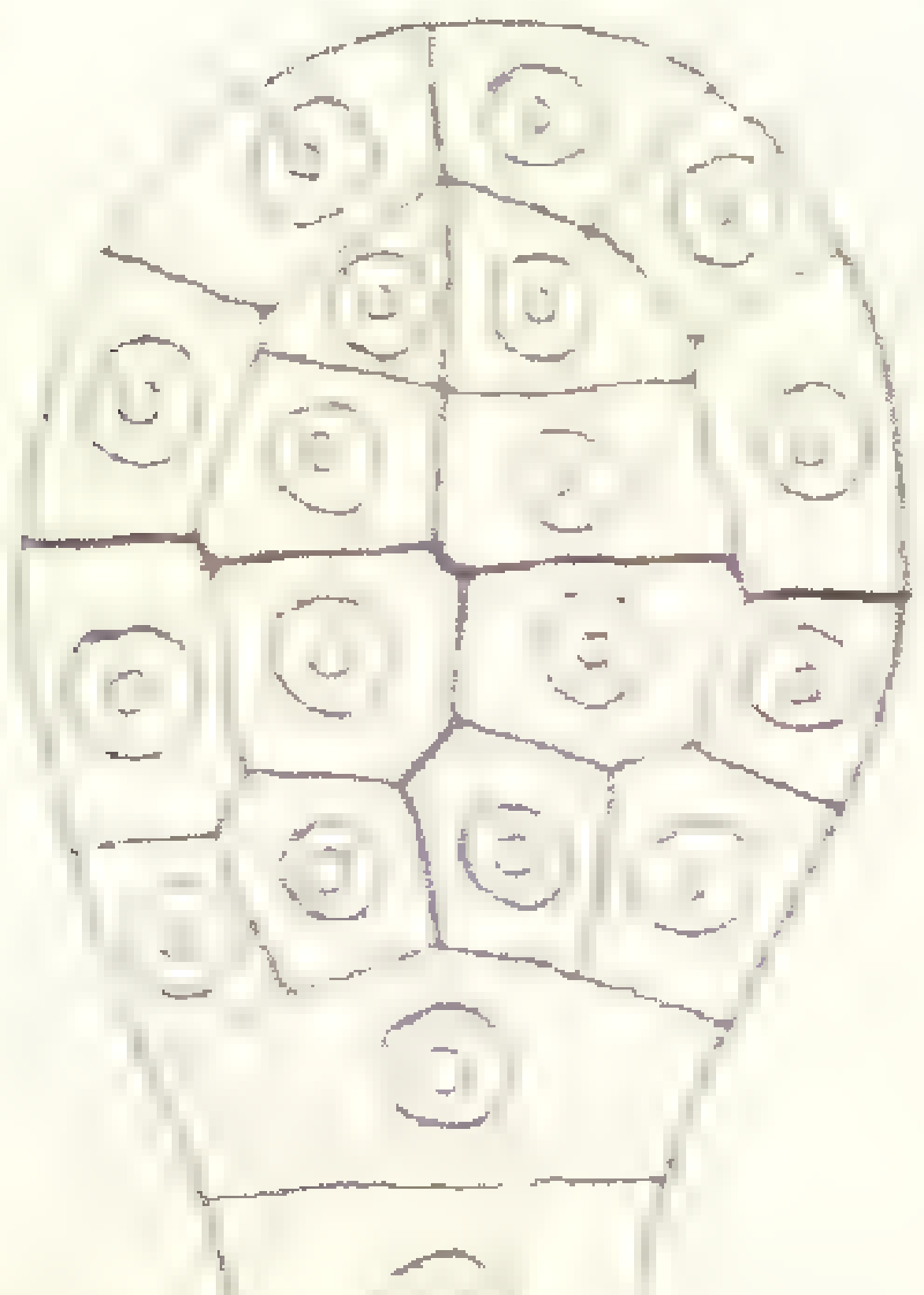

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CHAMBERLAIN on SALIX.

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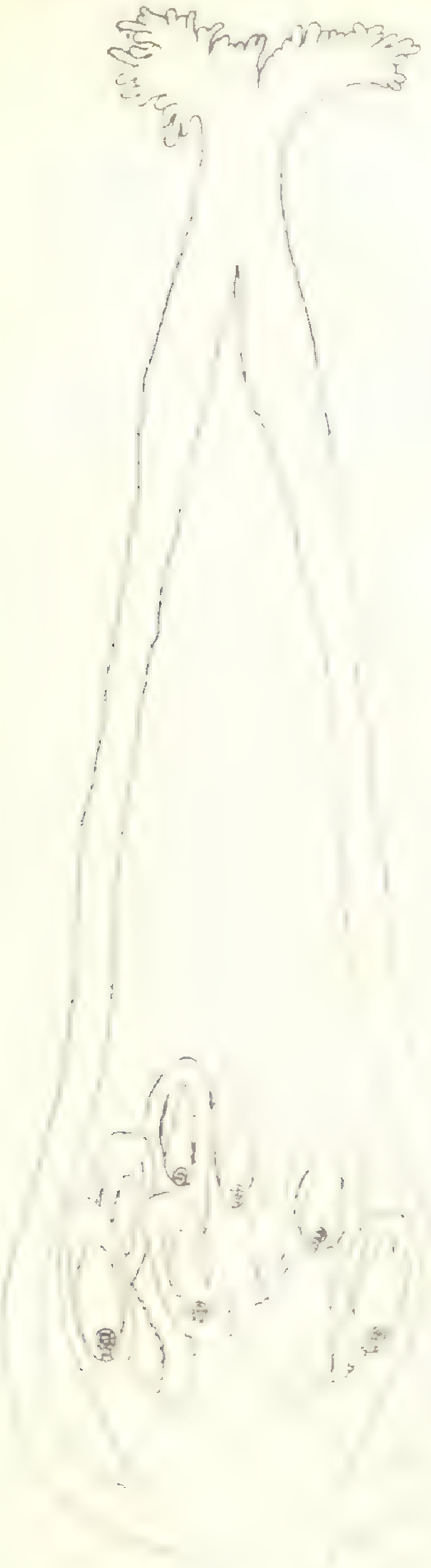
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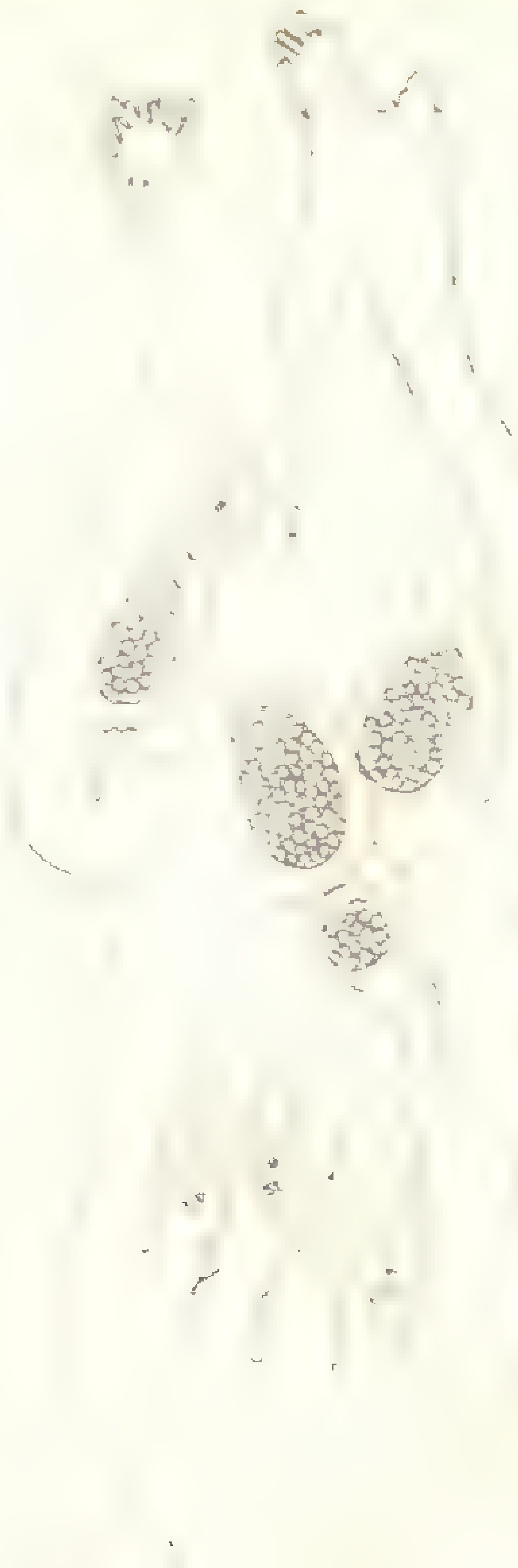
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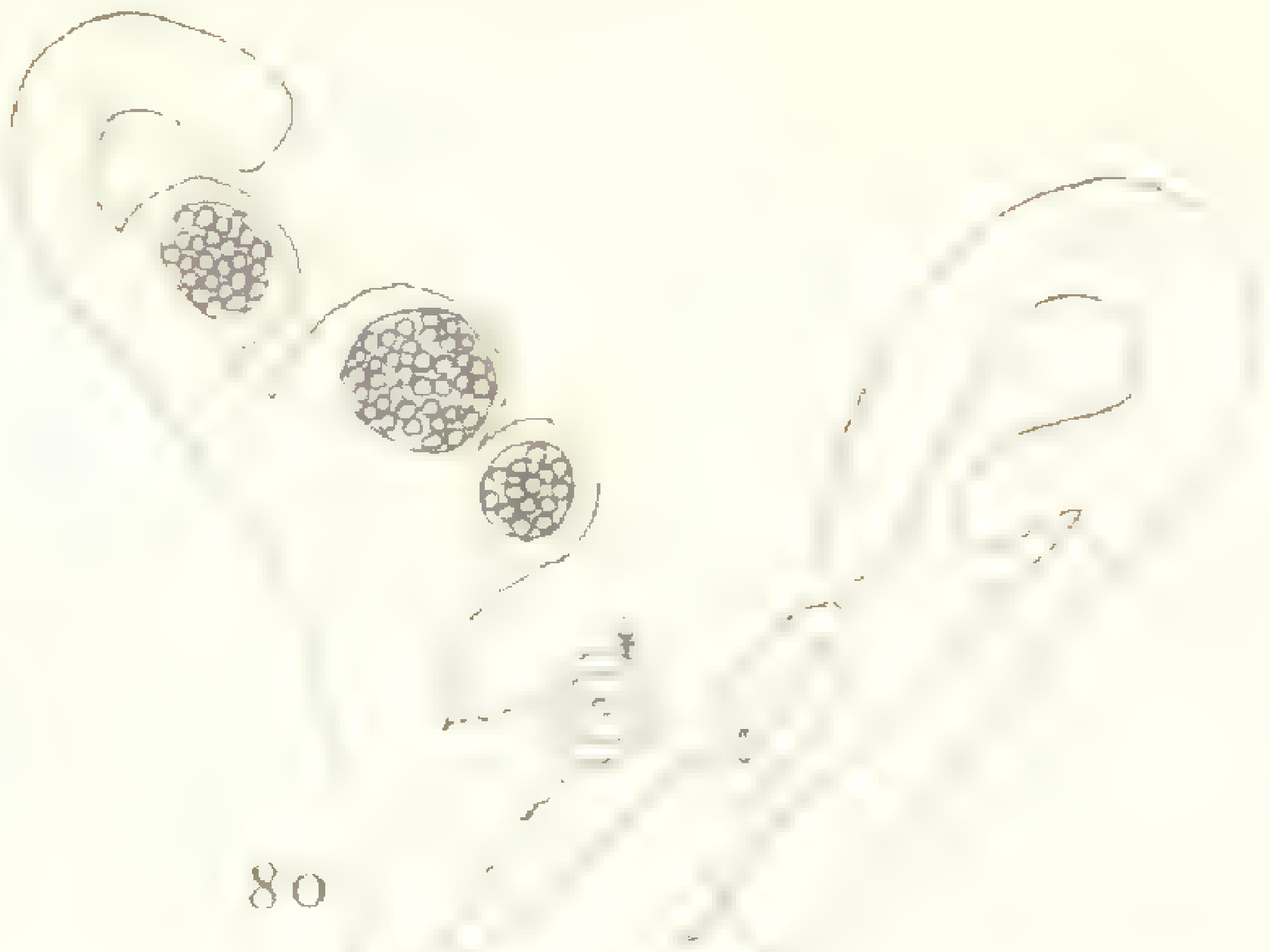
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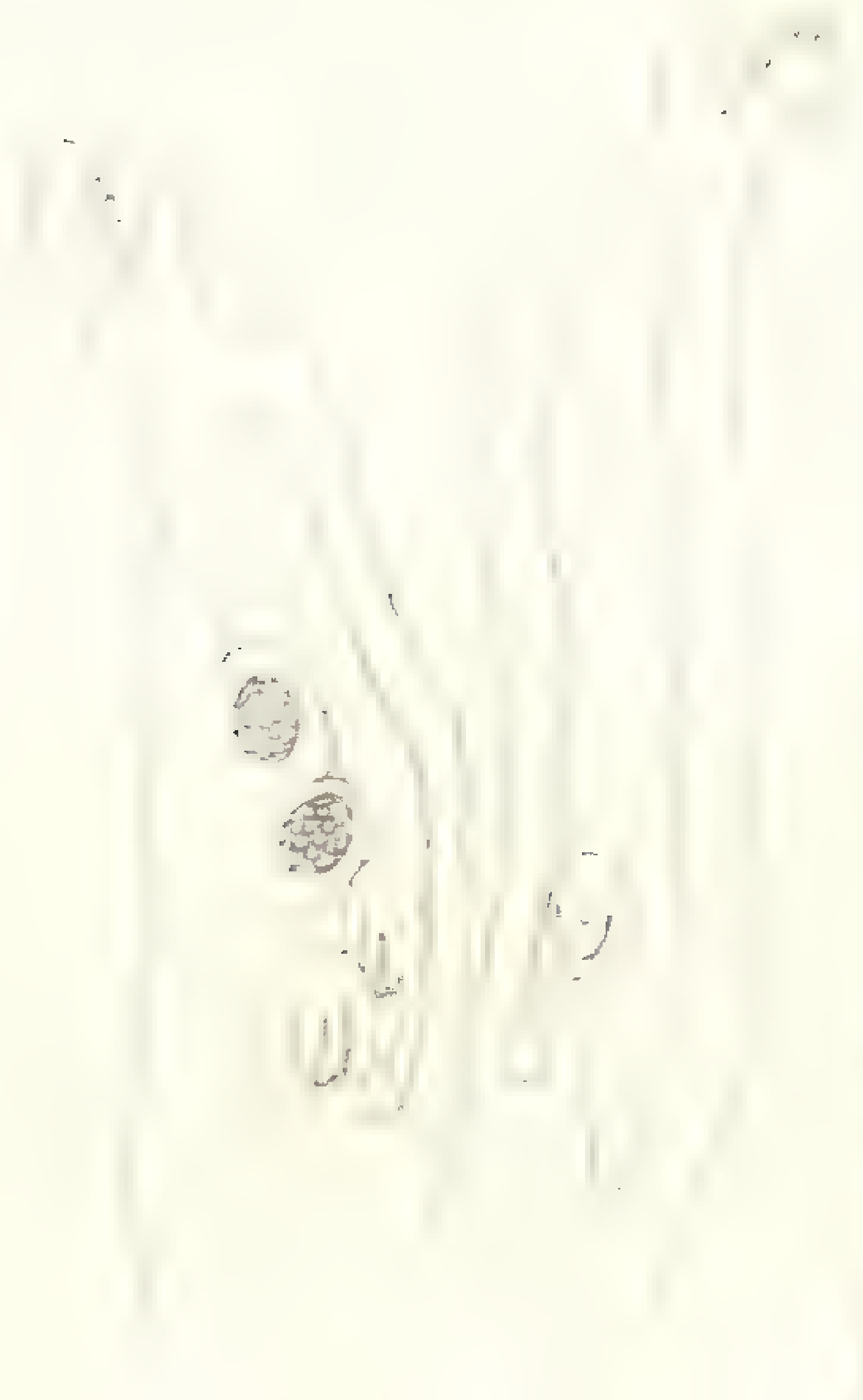
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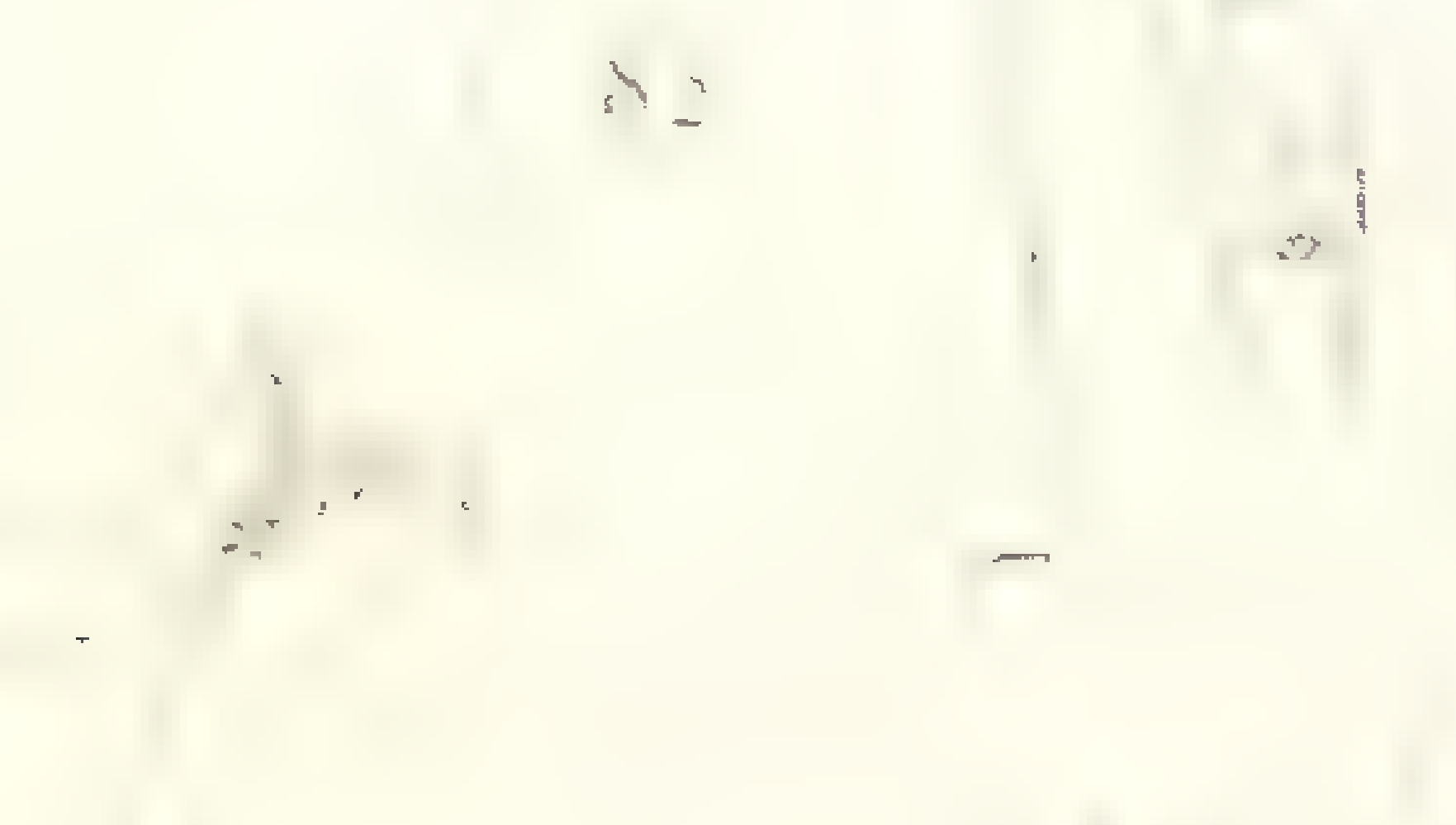
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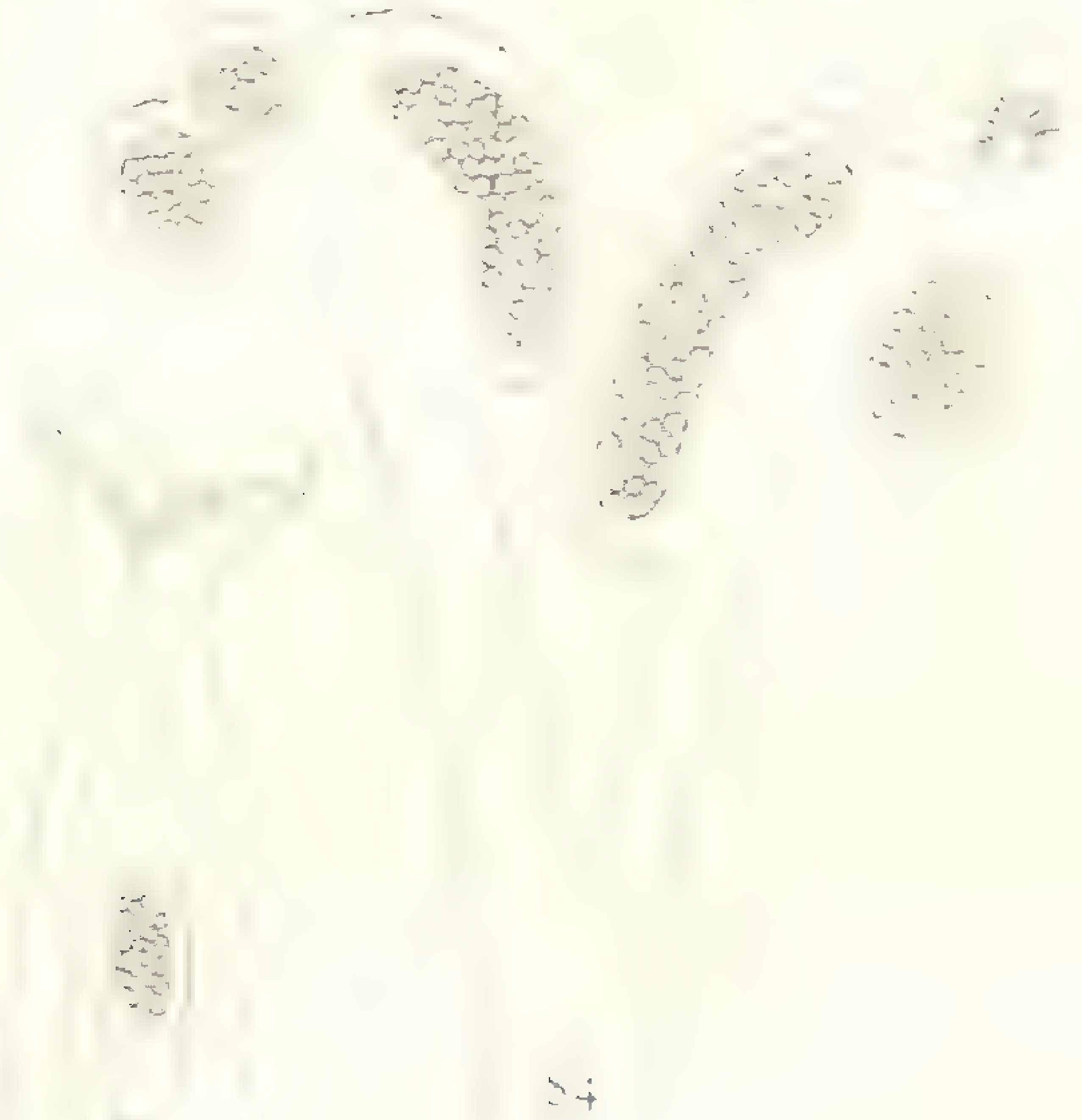
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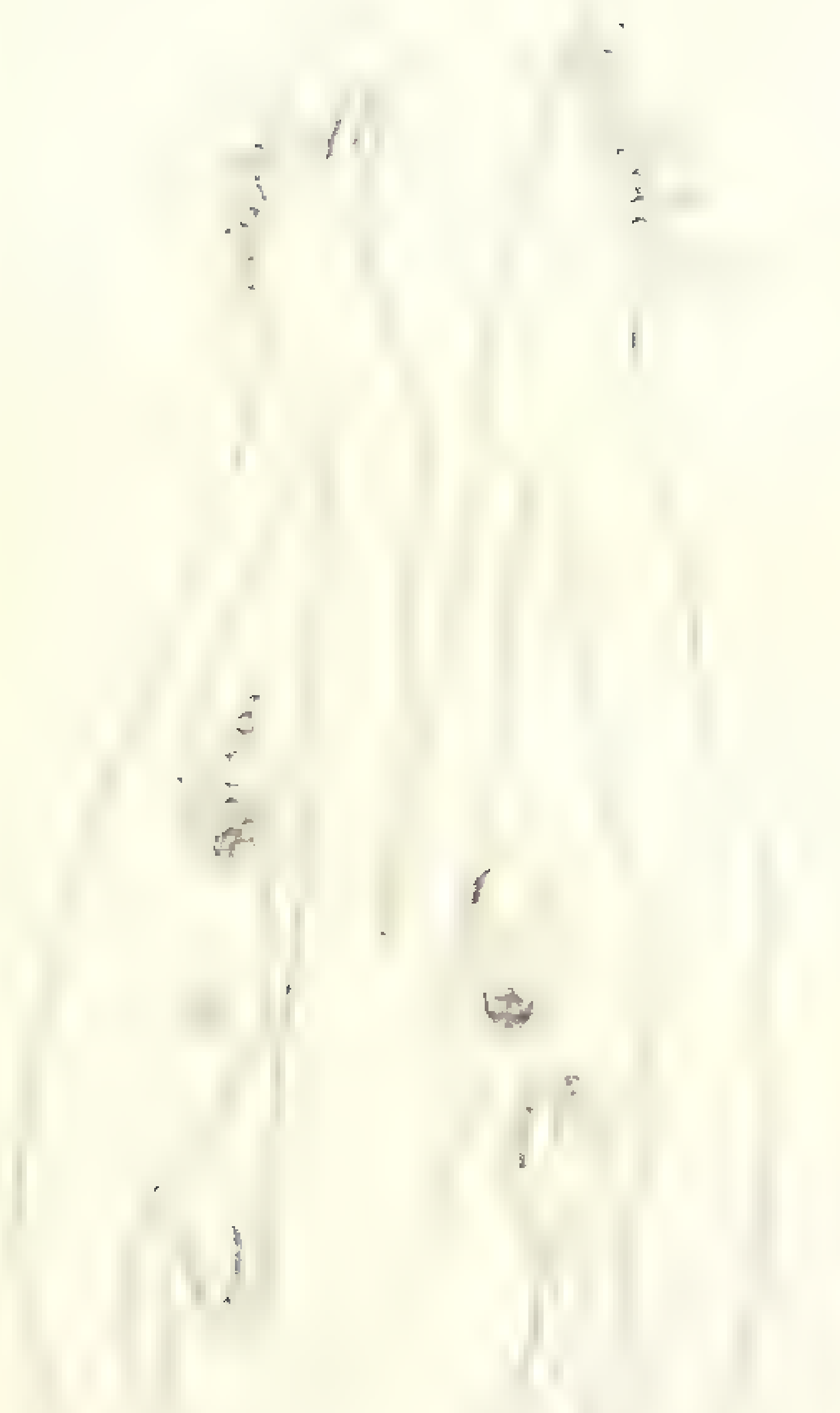
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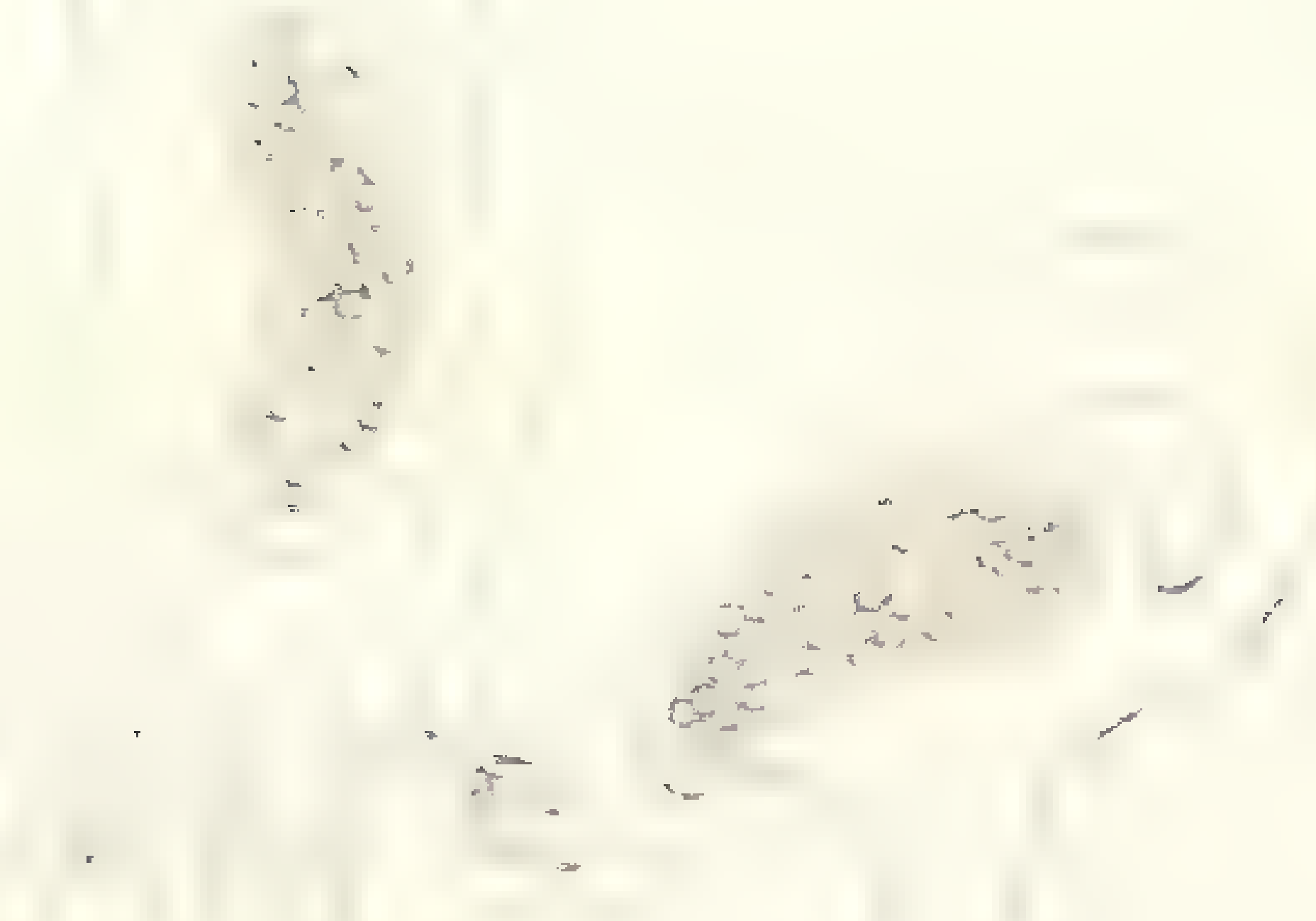
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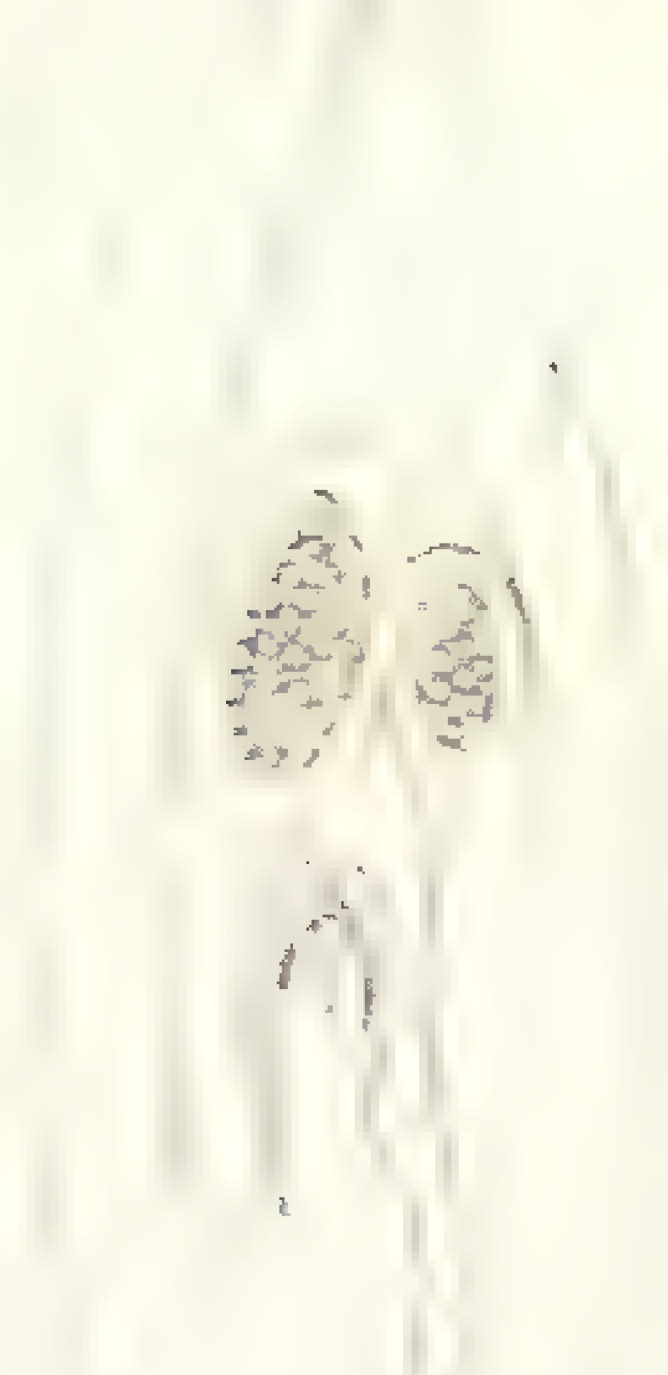
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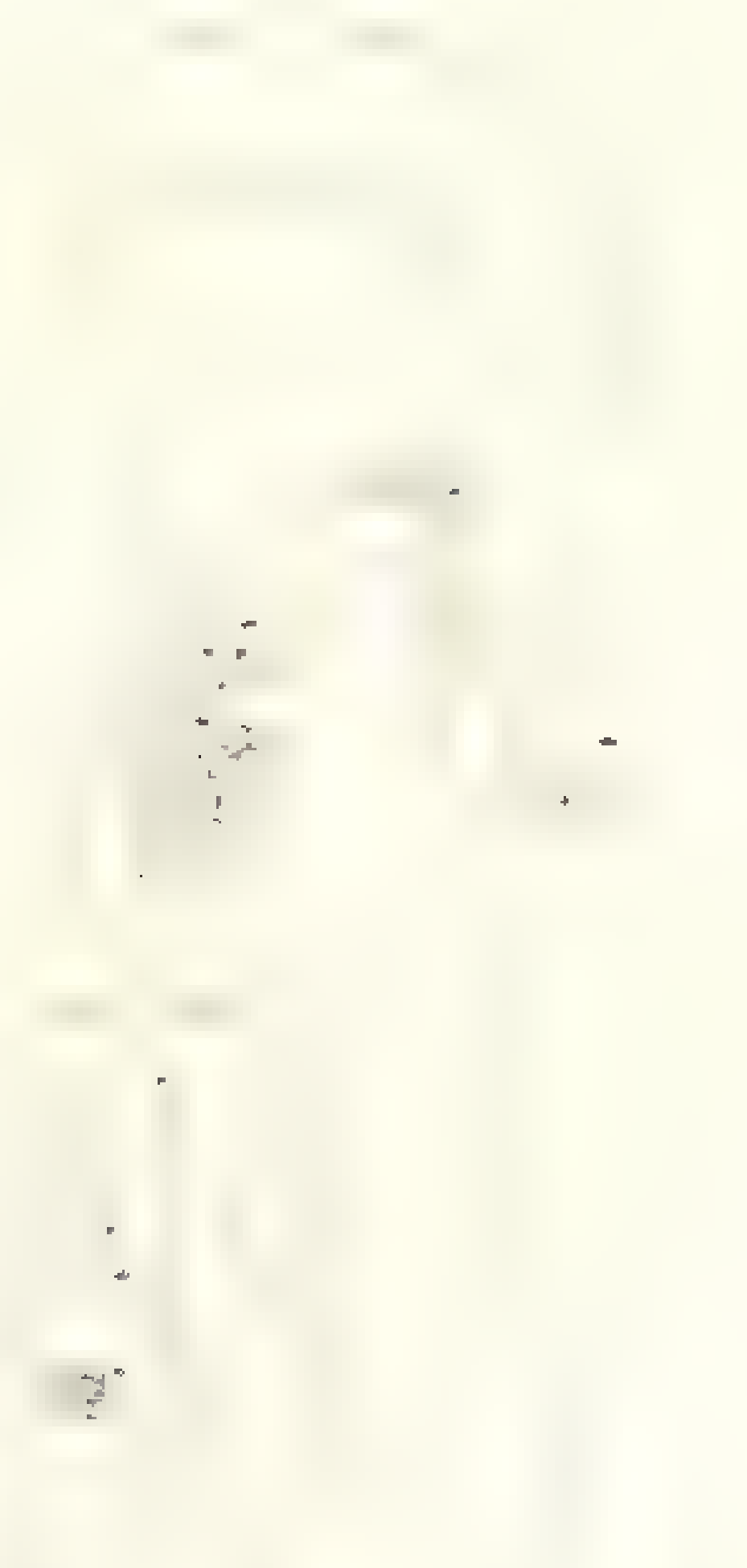
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CHAMBERLAIN on SALIX.

FIG. 74. *S. tristis.* Embryo almost in cotyledon stage; dermatogen of root tip differentiated but still no separation into periblem and plerome.

FIG. 75. *S. glaucophylla.* Shows dermatogen of root tip and the root cap; no differentiation into periblem and plerome.

FIG. 76. *S. tristis.* Dermatogen of root tip and several layers of the root cap; periblem and plerome are probably independent.

FIG. 77. *S. glaucophylla.* The lower karyokinetic figure marks the division by which the suspensor contributes the dermatogen of the root tip and first layer of the root cap.

FIG. 77*a*. *S. glaucophylla.* A somewhat later stage than *fig. 77*.

PLATE XVIII.

FIG. 78. *S. petiolaris.* A normal pistil drawn for comparison.

FIGS. 79–88. *S. petiolaris.* All drawn from material taken from a single monstrous plant. A short description of each figure is given in the text.

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. XXXVIII.

NOTES ON THE GENUS CALOSTOMA.

CHARLES EDWARD BURNAP.

(WITH PLATE XIX)

THE genus Calostoma comprises a small group of gastromycetous fungi of peculiar habit which, though widely distributed geographically, are by no means well known as regards their developmental history. Even the commonest species, which is also the best known member of the group, and is met with not rarely in the whole eastern section of the United States, has never been obtained in a condition to show clearly the earlier phenomena connected with its spore formation. The lack of any definite information on this point has rendered the immediate affinities of the genus a matter of some uncertainty, and the present paper is offered as a slight contribution on the subject, based upon the examinition of material in unusually good condition collected by Dr. Thaxter in the vicinity of New Haven, Conn. The fact that this fungus passes its early stages just below the surface of the ground and is usually protruded only after the elements of the gleba, or spore bearing portion, have disappeared by absorption, renders it very difficult to procure in a young condition. The present material was obtained just as the plant was beginning to appear at the surface in a spot which had been marked during the previous season with this end in view. In addition to this young material just mentioned I have had access to specimens in Dr. Thaxter's herbarium, and the collections in the laboratory and herbarium of the Cryptogamic Department of Harvard University, including the collection of Dr. Curtis.

Although one of the American species of Calostoma was described as early as 1691, the first extended account of the development of any member of the genus is that given by Fischer in 1884, in which the morphology and development of *C. cinnabarinum* are fully and correctly described. The material, however, on which this account was based does not seem to have been in condition to show the development of the gleba, except to a limited extent. The only remaining contribution of importance which relates to the morphology of the genus is that contained in the monograph published by Massee in 1888, where the development of *Calostoma cinnabarinum*, based upon specimens in the Kew Herbarium, is described in some detail. To this description we shall have occasion to refer presently.

At maturity *C. cinnabarinum*, which is the most common American species and may serve as a type for the whole genus, presents the appearance of an ochraceous globose body opening above by a stellate mouth guarded by toothlike valves, and extending below into a footstalk composed of anastomosing strands. The gleba lies at the center of the globose body, and is surrounded in its younger stages by four layers: (1) the volva, an outer gelatinous layer which soon disapppears; (2) the exoperidium, a layer just within the volva, also breaking away at an early stage; (3) the endoperidium, which is the external layer in older specimens; and (4) the spore sac containing the gleba.

Before passing to the development of the gleba, the other elements of the plant may be described briefly, further details concerning which may be sought in the accounts of either Fischer or Massee already referred to.

The volva, which envelops the fungus in its early stages, is composed of a homogeneous gelatinous mass arising from the gelatinification of the walls of a layer of hyphæ which are found imbedded in it and are developed in a radial direction from the exoperidium which lies next to it. When swollen by water, as it usually is in a state of nature, it constitutes a viscid jelly-like mass which soon becomes ruptured at the apex, partly through its own deliquescence, and partly by the protrusion of the inner elements up through it. At this stage it is separated from the exoperidium except at the base, and sinks to the ground from its own weight (*fig. 4*), after which it deliquesces, and leaves but a slight trace of itself around the base of the footstalk and exoperidium.

The hyphæ found imbedded in the volva extend inward and form the exoperidium in which three rather distinct zones occur. The first or outermost is composed of branching hyphæ which run parallel with the periphery. In the middle zone the branching and anastomosing hyphæ run in a radial direction, becoming thicker as they extend inward, and soon pass over into the third zone in which the hyphæ are closely interlaced, and have their thick walls beset with numerous red granules. The hyphæ of the outer and middle zones lie imbedded in a mucilaginous substance which when dry gives the exoperidium a horny consistency, but when moistened swells considerably.

At first the hyphæ of the innermost layer of the exoperidium pass inward and are in connection with those of the endoperidium, but through the disintegration of the walls of the hyphæ forming the inner portion of the granular zone a separation soon takes place between these two layers. Owing partly to the distention of the endoperidium with its contained elements, and partly to the elongation of the footstalk in the region between the exoperidium and the endoperidium, the former is ruptured more or less irregularly around the base, at the same time splitting from below upward into numerous laciniæ, while not uncommonly a similar splitting may take place at the apex. As a result, the exoperidum becomes divided into numerous irregular segments which curl spirally either outward or inward, according as the mucilaginous substance in its outer zone is dry and contracted or moist and swollen. In this manner the exoperidium is finally removed by a process of peeling, so that in the more mature state little or none continues attached to the plant, the remainder lying about the base in the form of spirally twisted fragments.

The endoperidium is composed of thick walled closely interlaced hyphæ, and is of an extremely hard and enduring character, readily hibernating without injury. Its apex protrudes as an umbonate elevation which has from four to seven slits radiating from a center and dividing into a corresponding number of tooth-like valves, the inner surfaces of which are of a brilliant vermilion. The basal portion of the endoperidium forms the point of origin of the footstalk, which extends downward and breaks through the exoperidium in such a manner as to enclose completely patches of the red granular zone (*fig. 6, d*). Upon passing out of the endoperidium into the footstalk the hyphæ form themselves into anastomosing gelatinous strands (*fig. 6, b*) which give it the peculiar reticulate appearance seen in the mature specimens.

The tooth-like valves already mentioned open into the spore sac, which is composed of hyphæ somewhat smaller in diameter than those of the endoperidium. In the earlier stages the spore sac and endoperidium are in connection throughout, but a separation soon takes place, except at the apex in the region around the mouth where the connection between the two layers persists. After this separation the spore sac gradually contracts as the spores are discharged, so that a cavity is left between it and the endoperidium.

The hyphæ of the wall of the spore sac continue inward and form the gleba, which is of a yellowish color, and, when seen in cross section in its early stages, has a lobulated appearance, the cleft-like cavities between the lobules being traversed by loose strands of large brownish yellow branching hyphæ which form an irregular network (*fig. 5*). These hyphæ (*fig. 7*) are 3–4 μ thick, with frequent septa and clamp connections, and are marked with irregular transverse thickenings (*a*). They appear to have no connection with the fertile hyphæ; a fact which, together with the presence of the annular thickenings, would seem to indicate that they may represent a rudimentary capillitium, although I have not been able to find them after the spores arrive at maturity.

The fertile hyphæ are about 3 μ thick, much branched and bent and of a yellowish color. At an early period of their development they are thickly beset with numerous small rounded wart-like protuberances, and also short secondary branches of a smaller diameter than the primary hyphæ (*fig. 8, b*). At this stage, also, numerous oblong cells are developed from the fertile hyphæ which give to the gleba a characteristic appearance. These cells (*fig. 8 a*), which are at first globose, but at maturity become slightly oblong, are found borne upon the primary hyphæ, either laterally or terminally, in the center of a cluster of secondary branches which grow up around them. At maturity they are easily detached and may be seen isolated and scattered in all directions in the gleba as spore-like bodies measuring from 4–7×7–11µ. It is probable that these are the cells to which Fischer (1884) refers as occurring between the hyphæ of the gleba. On the further development of the gleba these cells entirely disappear through absorption, while the secondary branches which surround them develop into hyphæ bearing the basidia. Before this takes place, however, the spore sac, with the exception of a small area at the apex, becomes separated from the endoperidium, thus greatly reducing the surface upon which the gleba can draw for nutriment. The fact that the oblong cells disappear soon after this separation takes place may perhaps indicate that their function is to serve as reservoirs of food for the later stages of the other elements of the gleba.

As has just been stated, after the disappearance of the oblong cells above described, the secondary hyphæ are found to have developed considerably, and at the ends of their numerous branches the basidia are borne. These hyphæ have by this time increased to the diameter of the primary hyphæ, and like them are beset with numerous wart-like protuberances. The basidia (*fig. 9*) are usually club shaped, but vary widely; oftentimes being very nearly cylindrical and of the same diameter as the hyphæ which bear them, and from which they are separated by a transverse septum. The spores, which at first are subglobose and later become ellipsoid and punctate, are borne laterally as well as terminally; being more or less evenly distributed over the whole surface of the basidium, as in Tulostoma. The number occurring on a single basidium varies from five to ten or twelve. My material contained no specimens with the mature spores still *in situ;* but in that which I examined, although the spores were considerably advanced, there were no sterigmata.

In his monograph, already referred to, Massee describes and figures the basidia as "broadly obovate, measuring from 40–50 × 15–20μ, and bearing five or sometimes six spores supported on minute wart like prominences arranged in a circle around the apex." In my material, however, the position of the spores is very characteristic, and in no specimen which I examined were they in the least confined to the apex of the basidia, nor did they show any tendency to a circular arrangement in this region.

The fact that the spores are borne laterally upon the basidia in Calostoma seems to point at once to its affinity with Tulostoma, the only other gastromycete in which the spores are similarly borne. Fischer is of the opinion that the double peridium in Calostoma indicates its affinity with Geaster; a view also supported by Massee. The latter observer homologizes the external peridium of Geaster with the exoperidium and endoperidium of Calostoma, and the inner peridium of Geaster with the spore sac in Calostoma. He calls attention, however, to the wide difference which exists in the fact that in Geaster the inner peridium is confluent with the base of the outer peridium, while in Calostoma what he considers as the morphological equivalents of these two elements are confluent at the apex. The affinity of Calostoma with Tulostoma, however, seems to offer a more simple explanation of the facts. If we consider that the part of the peridium immediately surrounding the gleba in Tulostoma becomes differentiated to form the spore sac, but still remains attached to the outer shell of the peridium (endoperidium) at the apex, and that the rest of the peridium becomes differentiated into three layers (volva, exoperidium, and endoperidium), we see how readily the differences between the two genera may be explained. Both Calostoma and Tulostoma agree in being forced to the surface by the extension of a footstalk. In

Calostoma this footstalk is surrounded in its younger stages by the volva and exoperidium, and is plainly seen to arise from the endoperidium (*fig. 6*). In Tulostoma the footstalk is likewise surrounded in its younger stages by a portion of the peridium, which we may consider to be equivalent to the volva and exoperidium in Calostoma, and the inner region of the peridium from which the footstalk arises is probably the morphological equivalent of the endoperidium.

The similarity which exists between the basidia of the two genera is very close indeed, the greatest difference being that in the species of Calostoma under consideration the number of spores on a single basidium is considerably larger. Schrœter's original figure of the basidia of Tulostoma represents the spores with scarcely any sterigmata, and in his description he speaks of their nearly sessile character, so that the difference which exists in this respect is very slight.

Briefly stated, then, the evidence which seems to point to the affinity of Calostoma with Tulostoma rather than with Geaster, is found in the fact that both genera possess a form of basidium found in no other gastromycete, while the basidia of Geaster are entirely different; and that in explaining the differences which exist between Calostoma and Tulostoma by a simple process of evolution, no such obstacle has to be overcome as is found in the fact that, in Calostoma, the spore sac and endoperidium are united at the apex, while in Geaster what Massee considers their morphological equivalents are united at the base.

The anomalous character of such a type of basidium in so highly developed a gastromycete, which finds its only parallel within the group in the four-spored basidia of Tulostoma, is a matter of some interest in connection with any attempt to draw comparisons between the typical basidiomycetes and the supposed transitional forms. In the present instance it must be admitted that (assuming the basidial nature of the sporophores of Pilacre) the peculiar basidia just described, together with the number, position and sessile character of the spores, would render comparatively easy the steps from the angiocarpous Protobasidiomycetes of Brefeld's "system" to the typical Gastromycetes.

From a systematic point of view the American species of Calostoma are not without a certain interest, especially in connection with the uncertainty which has prevailed concerning the distinctions existing between *C. cinnabarinum* and *C. lutescens*. The earliest reference to either of these species is, so far as can be ascertained, that which is made by Plukenet in his *Phytographia* (1691), where, as pointed out by Farlow (1887), a fungus, probably referable to *C. cinnabarinum*, is figured and briefly described as follows: "Fungus pulverulentus virginianus caudice corallino topiario opere contorto." More than a century later Persoon (1809) described and figured one of the American forms under the name of *Scleroderma callostoma*, remarking that if many species with a similarly shaped mouth were found a new genus should be formed, and later in the same year Desvaux (1809) established this new genus, giving it the name of Calostoma, and describing the only American species then known as *C. cinnabarinum*. In 1811 Bosc again described it as *Lycoperdon heterogeneum*, probably not having seen either Persoon's or Desvaux's description, as he makes no reference to them. Like Persoon, Bosc states that it should form a new genus, and in 1817 Nees von Esenbeck, who was also evidently ignorant of the description of the two last named authors, for a second time places it in a new genus, calling it *Mitremyces heterogeneus*. In 1825 Edward Hitchcock in an article on *C. cinnabarinum* in *Am. Jour. Sci.* calls it *Gyropodium coccineum*, a name which he ascribes to Schweinitz, but evidently upon no published authority. Later Corda in 1842 retains both the generic names of Calostoma and Mitremyces, referring *C. cinnabarinum* to the former and *C. lutescens* to the latter; while lastly in 1888 all the species of the genus were returned by Massee to the older name of Calostoma.

The genus contains ten species, which are widely distributed; occurring in America, Australia, southern Asia, and the Malay Archipelago.

The similarity in the appearance of *C. lutescens* and *C. cinnabarinum* has led to the confusion which has existed concerning their distinctions. Schweinitz in 1822 described a form from Carolina as *M. lutescens* and later in 1831 a second species as *M. cinnabarinum*. Sprengel (1827), Fries (1849), and Nees, Henry, and Bail (1837) all give *M. lutescens* as the only American species, but Corda, as we have just seen, gives also *Calostoma cinnabarinum*, without being aware of its generic connection with *Mitremyces lutescens*. Massee in his monograph states that owing to the considerable variations in size, color and form which *C. cinnabarinum* presents he is of the opinion that the *Mitremyces lutescens* of Schweinitz is but a young condition of his *M. cinnabarinum*, and unites the two under this name. The only reference made to the shape of the spores of *M. lutescens* by the early observers is found in the description of Corda, who states that they are globose. *Calostoma cinnabarinum*, on the other hand, as is well known, has ellipsoid punctate spores. Among the specimens contained in the Curtis collection and labeled *M. lutescens* are two examples, however, one from Alabama (coll. *Peters*), the other from West Virginia (coll. *A. H. Curtiss*), which agree with Corda's description in possessing globose spores. They further differ from *C. cinnabarinum* in having a longer footstalk, the gelatinous strands of which are finer and more closely woven, while the color is of a more uniform pale yellowish. The length of the footstalk (*fig. 1*) was as much as 9^{cm}, although part of it had evidently been broken off at the base, and in a fresh state it might have been even longer.

These two dried specimens were the only material of *C. lutescens* which I was able to examine, but they indicate that Massee was in error in considering the species identical with *C. cinnabarinum*, and that, while it is probably the globose spored form to which Schweinitz gave the name of *M. lutescens*, it is, with little doubt, the form which Corda describes by that name. The "*M. lutescens*" from Ceylon described by Massee as *C. Berkeleyi* is identical with the American form as far as concerns the character and measurements of the spores. The habit, however, as represented in Massee's figure does not present the same peculiarities which appear to distinguish our species.

Another small species from South Carolina was first described in 1857 by Berkeley as *M. Ravenelii.* It is smaller than the other two American forms, and further differs from them in the fact that its exoperidium often remains attached to the endoperidium in the form of wart-like protuberances.

Three American species may then be distinguished as follows:

CALOSTOMA CINNABARINUM Desv. *Plate XIX, figs. 3–10.*

Fungus pulverulentus Plukenet, Phytographia *pl. 184. fig. 5.* 1691.

Calostoma cinnabarinum Desvaux, Jour. de Bot. **2**: 94. 1809.

Scleroderma calostoma Persoon in Desv., Jour. de Bot. **2**: 15. *pl. 2. fig. 2.* 1809.

Lycoperdon heterogeneum Bosc, Mag. Ges. Nat. Fr. **5**: 87. *pl. 6. fig. 10 a, b.* 1811.

Lycoperdon calostoma Poir. Encycl. Suppl. **5**: 476. 18—.

Mitremyces heterogeneus Nees, Syst. der Pilze und Schwämme 136. *pl. 11. fig. 129a.* 1817.

Gyropodium coccineum Hitchcock, Am. Jour. Sci. **9**: 56. *pl. 3.* 1825.

Mitremyces cinnabarinum Schweinitz, Syn. Fung. Amer. Bor. in Amer. Phil. Soc. 255. no. 2244. 1831.

Mitremyces lutescens Ell. & Ev. Fung. Columb. 799, N. A. F. 727; Rav. Fung. Car. **1**: 76.

Exoperidium vermilion within, breaking at base, sometimes at apex also, into laciniæ. Endoperidium ochraceous, often slightly vermilion; ostiolum vermilion, teeth 4–7. Footstalk reddish brown or brownish, 1–6^{cm} long by .75–3^{cm} wide. Spores elliptic-oblong, echinulate or punctate, pale ochre yellow, 15–18 × 8–10μ.

Eastern part of the United States: Massachusetts (*Faxon*), Pennsylvania (*Schw.*), Carolina (*Rav.*), Texas (*Drum.*), Ohio (*Morgan*), Tennessee and Connecticut (*Thaxter*).

It makes its appearance above ground towards the end of July, and is more commonly found growing in rather moist situations along the banks of streams in woods, sometimes occurring in dryer localities. Although under the ordinary powers of the microscope the spores appear echinulate, examination with higher magnification shows them to be rather punctate, the points corresponding to striations in the spore wall as is shown in *fig. 10a.* The surface of the spore may also be covered with a flaky incrustation present in small irregular patches as in *b*.

CALOSTOMA LUTESCENS (Schwein.) *Plate XIX, figs. 1, 2.*

Mitremyces lutescens Schweinitz, Syn. Car. p. 60 no. 345. 1822; Corda, Anleitung, 79, *pl. D. fig. 41, nos. 15–17.* 1842.

Calostoma cinnabarinum Massee *pro parte*, Annals of Botany **2**: 42. 1888.

Exoperidium light yellowish. Endoperidium smooth, yellowish, ostiolum pale vermilion within. Footstalk longer, its strands somewhat finer than in the last species, yellowish, $7–9^{cm}$ long by $.75–2^{cm}$ wide. Spores globose, verrucose, $7–9\mu$.

Alabama (*Peters*), West Virginia (*A. H. Curtiss*).

Several specimens in the Curtis collection are labeled *M. lutescens*, only two of which appear really to belong to this species. Although the age of the specimens does not admit of any accurate description of their gross appearance, they seem to differ from *C. cinnabarinum* in their pale yellowish color and longer more highly developed footstalk, which appears to attain a greater length than is ever seen in the last mentioned species. The endoperidium, when it still remains, is yellowish within and without, a fact which may be due to its being faded with age. The inner faces of the teeth, however, have a distinct vermilion tint. The round verrucose spores which vary greatly in size at once distinguish the species from *C. cinnabarinum*, and as already mentioned coincide with the description given by Corda.

CALOSTOMA RAVENELII (Berk.) Massee.

Mitremyces Ravenelii Berkeley, Trans. Linn. Soc. **22**: 130. *pl. 25 B.* 1857.

Calostoma Ravenelii Massee, Annals of Botany **2**: 25. 1888.

Smaller than last two species, the exoperidium remaining attached to the ochraceous endoperidium in the form of irregular warts or scales. Footstalk short. Spores elliptic oblong, smooth.

North and South Carolina, "upland and deadwood" (*Curtiss*).

Although Morgan considers the species as synonymous with *M. lutescens*, it appears to differ in its uniformly smaller size and ill-developed footstalk, as well as by its different color and the peculiar mode of rupture of its exoperidium, which remains attached in scale-like fragments all over the surface of the endoperidium, the Herb. Curtis specimens agreeing in this respect with those of Berkeley as figured by Massee, while the smaller smooth spores described and figured by the last named writer would constitute an additional point of difference.

In closing I wish to take this opportunity to acknowledge my indebtedness to Dr. Thaxter for the very great assistance which he has rendered me in preparing this paper.

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EXPLANATION OF PLATE XIX.

Calostoma lutescens.

Fig. 1. Gross habit drawn from dried specimens.

Fig. 2. Three spores showing ordinary variation in size. Obj. J. oc. 4.

Calostoma cinnabarinum.

Fig. 3. Gross habit after disappearance of volva and exoperidium; fragments of the latter (*c*) still remaining; *a*, mouth; *b*, endoperidium; *d*, footstalk.

Fig. 4. Specimen from which the volva has been partly removed through deliquescence. The exoperidium is shown splitting from the base upward.

Fig. 5. Section through a portion of the gleba showing the rudimentary capillitium (*a*) extending inward from the wall of the spore sac (*b*) and forming loose strands between the lobules of fertile hyphæ (the latter are not shown in the figure). Obj. A. oc. 4, Zeiss.

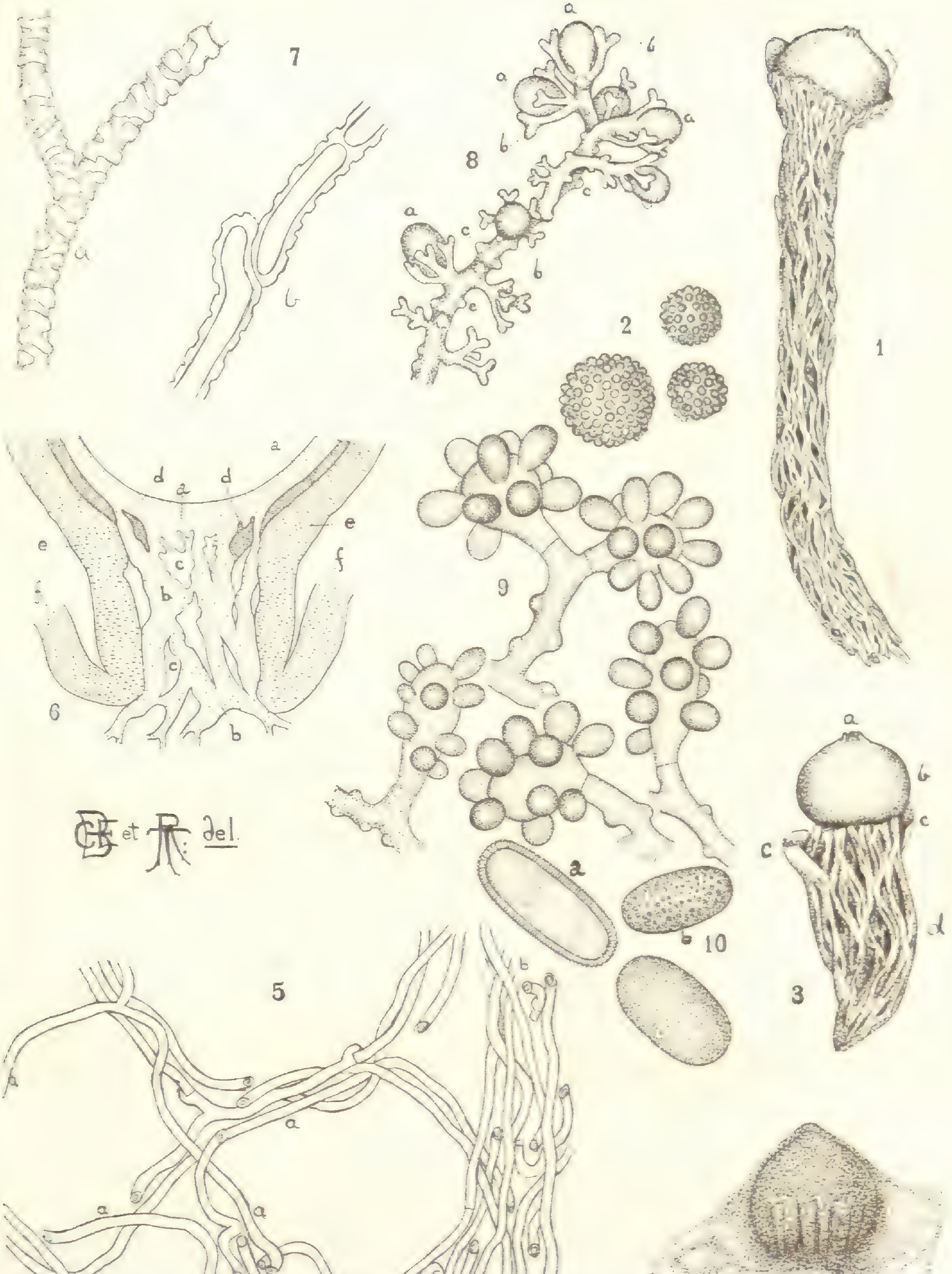
Fig. 6. Semi-diagrammatic section through the base of a young specimen; *a*, endoperidium extending downward to form the strands of the footstalk (*b*), which encloses cavities (*c*) and portions of the granular layer of the exoperidium at *d*; *e*, exoperidium; *f*, volva.

Fig. 7. Rudimentary capillitium showing superficial thickenings (*a*), clamp connection and septum (*b*).

Fig. 8. Portion of primary hypha showing the oblong cells (*a*) and secondary hyphæ (*b*), which later bear the basidia; *c*, wart-like projections from primary hypha. $\frac{1}{12}$ oil, oc. 4.

Fig. 9. Five basidia with developing basidiospores. Obj. J. oc. 4.

Fig. 10. Three spores; *a*, optical section showing striation of wall. Obj. J. oc. 4.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BURNAP on CALOSTOMA.

BRIEFER ARTICLES.

DEFINITENESS OF VARIATION, AND ITS SIGNIFICANCE IN TAXONOMY.[1]

In descriptive and systematic botany we have just two things with which to deal, types and variants. The types are the comparatively absolute standards by which we measure the variations; but the variants occupy most of our attention. The type is the one fixed point for each species, while the limitations which we fix for the species represent the extent of possible (permissible) variation from the type as determined by our arbitrary species measure. The ideal way to study systematic botany would be to keep the types always before us, and to describe each specimen by computing its variation from this or that type. This is, in fact, what critical study amounts to. In other words, the systematist is always measuring and classifying variations. If, therefore, definite lines of variation can be traced, it ought to be a matter of great convenience.

The two opposing schools of evolutionary philosophers are divided at present as to whether variations actually do occur in definite directions or not. But even Weismann[2] wrote in 1875, perhaps before he was so strongly confirmed in his present position, "the evolution of the species of Deilephila shows that the evolution of the marking follows throughout a certain law; that it proceeds in all species in the same manner. All species seem to steer towards the same point, and this gives the impression that there is an internal law of evolution which, like an impelling force, determines the future phyletic modification of the species."

The Neo-Lamarckians are very positive on this point. Eimer[3] says "I have, from the zoological standpoint, pointed out and emphatically maintained that the variation of species takes place, not in all directions irregularly, but always in definite directions: and indeed in any given species at a given time in only a few directions." Nägeli also asserts that "the transformation of varieties, species, genera, and families, is effected in definite directions, toward greater perfection, that is, toward greater complexity. Forms grow as it were toward greater perfection. This principle is of a mechanical nature, and constitutes the law of the persistence of motion in the field of organic evolution. Once the motion of evolution is started it cannot cease, but must persist in its original direction." Cope[4] takes advanced ground on this question. He says "variations are not promiscuous or multifarious, but are of certain definite kinds, or in certain directions."

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[1] Condensed from address before the Vermont Botanical Club, February 6, 1897.

[2] Quoted by Eimer, Organic Evolution, Eng. Ed., 73.

[3] Dr. G. H. Theodor Eimer, Organic Evolution.

So much for the philosophers. What are the facts? Every botanical variety represents with greater or less accuracy some definite line of variation from a specific type. Thus *Ambrosia trifida* L., of which the type has large, deeply three-lobed leaves, tends constantly to vary toward ovate or oval, undivided leaves, especially in the upper parts and in small plants. The most conspicuous of these variants constitute the variety *integrifolia* of Torrey and Gray. *Aster diffusus* Ait. is described as "more or less pubescent;" but those which are much "more pubescent" make up Gray's variety, *hirsuticaulis*. The common ox eye daisy, *Chrysanthemum Leucanthemum*, is notably variable, but the variations are principally in a few quite definite directions, the commonest being toward tubular or laciniate rays.

In horticultural botany we have still better opportunities of observing similar facts. A very striking case of variation in definite directions was worked out during the fall of 1896 by one of my students, Mr. V. A. Clark, in the case of *Coreopsis tinctoria* Nutt. This western composite has been widely introduced in gardens. French and German seedsmen offer many selected named varieties, most of which are sold in mixture by American dealers. These varieties, being well represented on our grounds, were suggested to Mr. Clark for study and classification. It could hardly have been an accident that the varieties, after careful study and quite without knowledge of any theory of variation, should have all fallen into one series. In this species the rays are yellow with a very small but variable maroon base. In the varieties this maroon marking constantly encroaches upon the yellow, until in extreme forms it quite supersedes the body color. One is given the impression that the maroon overlays the yellow in this extension; and this is progressively indicated by the very definite course of evolution in the marking of the under side of the ray also. For on the under side the brown appears first in the thinner portions of the ray, and last on the thick veins. It is as though the brownish pigments were spread first over the upper surface and subsequently increased in depth, first showing through in the thin areas.

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[4] E. D. Cope, Primary Factors of Organic Evolution 22.

Precisely the same series was later constructed from blossoms of the commercial *Freesia refracta alba* grown in our greenhouses. In this case we have a reversion from the highly selected white type. But the appearance of an orange yellow spot at the base of the upper petal and its extension over first the inner surface, and secondly its appearance on the backs of the petals, followed the same definite lines as those already studied in *Coreopsis tinctoria*. In this case sections were made through petals from various blossoms in the series. In the first appearance of yellow pigment it was confined to a single layer of subepidermal cells, and was from here subsequently propagated through the intermediate cells to the under surface of the petals.

This centrifugal encroachment of a darker upon a lighter color in blossoms is one of the commonest lines of definite variation. In *Lepachys columnaris* Torr. and Gray it gives the variety *pulcherrima* Torr. and Gray. In the florists' *Primula Chinensis* it gives the beautiful "Schwarzaugen" varieties of late German catalogues. With more or fewer exceptions the same method governs the variations in markings of marigolds, verbenas, phloxes, poppies, pelargoniums, irises, and dozens of other species and genera which will readily occur to the gardener.

It is quite remarkable that any given lot of variations should happen to fall into one continuous series; and this becomes of still greater importance when found to hold true with groups of highly cultivated and severely selected plants, like the Coreopsis and Freesia cited. It is no longer final to say that variations "are as definite as the changes in environment are, which determine and control their existence,"[5] for the gardener seeks variations in all directions, and inasmuch as he controls both environment and selection, he will preserve and augment whatever variations nature may give him. If, in such cases, variations are to be systematized with comparative ease, a careful study along similar lines ought to give some clue to a better understanding of troublesome variations in many of our unstable wild species.—F. A. WAUGH, *University of Vermont.*

[5] L. H. Bailey, Survival of the Unlike 23.

ALGÆ EXSICCATÆ.

Parts 26–29 (nos. 1201–1400) of "*Algæ aquæ dulcis exsiccatæ* præcipue scandinavicæ, quas adjectis algis marinis chlorophyllaceis et phycochromaceis distribuerunt Veit Wittrock, Otto Nordstedt, G. Lagerheim," are now published. The following botanists have given most valuable aid by sending algæ from different parts of the world and by the determination of critical species: J. Anechavaleta, S. Berggren, K. Bohlin, F. Börgesen, O. Borge, E. Bornet, A. le Dantec, F. Elfving, Ch. Flahault, M. Foslie, M. Gomont, P. Hariot, K. E. Hirn, F. Hy, G. Istvánffi, F. R. Kjellman, L. Kolderup-Rosenvinge, C. A. M. Lindman, A. Löfgren, G. Malme, C. Ostenfeld-Hansen, W. Schmidle, B. Schröder, W. A. Setchell, and N. Wille.

These four parts contain algæ from Sweden, Norway, Spitzbergen, Finland, Denmark, Germany, Hungary, Austria, Switzerland, France, United States of America, West Indies, Columbia, Ecuador, Brazil, Paraguay, Uruguay, Japan, Asia Minor, and New Zealand.

The following genera, species, and varieties are new to science: *Chætobolus lapidicola* Lagerheim, *Cladophora basiramosa* Schmidle, *Cœlastrum proboscideum* Bohlin, *Cosmarium sphærosporum* Nordst. var. *strigosum* Nordstedt, *Loefgrenia anomala* Gomont, *Œdogonium Landsboroughi* (Hass.) Kütz. var. *robustum* Wittrock, *Œ. Lindmanianum* Wittrock, *Œ. œlandicum* Wittr. var. *subpyriforme* Wittrock, *Œ. Wittrockianum* Hirn, *Spirogyra Malmeana* Hirn, *S. tuberculata* Lagerheim, and *Trochiscia sanguinea* Lagerheim.

The diagnoses of the new American species are as follows:

Coelastrum proboscideum Bohlin, nov. spec.—C. coenobiis vel tetraëdricis e 4 cellulis, vel cubicis e 8 cellulis compositis, diam. 10–21 μ; cellulis e vertice visis trigonis apicibus abruptis cohærentibus, extrorsum in processus singulos truncatos productis, membrana levi, 4–11 μ longis 5–13 μ latis; interstitiis coenobiorum tetraëdricorum trigonis, cubicorum tetragonis.

Aequatoriæ in scrobiculo rupis ad Agua clara provinciæ del Guayas 1891; legit *G. Lagerheim.*

LŒFGRENIA Gomont, nov. gen.—Planta myxophycea, filamentosa. Trichomata evaginata, basi affixa, pilifera, in parte inferiori passim ramosa, ramificatione vera. Heterocystæ nullæ. Hormogonia et sporæ usque adhuc ignota.

Lœfgrenia anomala Gomont, nov. spec.—Cæspites extensi, æruginei, vix millimetrum alti. Trichomata subrigida, inferne 2–4 μ crassa, e basi decumbenti et arcuata adscendentia, in pilum sensim ac longe attenuata, ad genicula eximie constricta; articuli prælongi, 12–24 μ æquantes.

Brasiliæ ad Sto. Amaro provinciæ Sao Paulo Batrachosperma aliasque plantas submersas investiens; legit *A. Löfgren.*

OEDOGONIUM LANDSBOROUGHI (Hass.) Kütz. β **robustum** Wittrock, nov. var.—Var. cellulis vegetativis crassioribus et brevioribus; oogoniis minus inflatis; oosporis oogonia complentibus;

crassit. cell. veget. plant. femin.	40—51 μ,	altit.	2—4 plo majore;
" oogoniorum	62—70 "	"	84—109 μ;
" oosporarum	60—74 "	"	78—100 μ.

Varietas hæc locum intermedium inter *Oe. Landsboroughi* α et *Oe. mexicanum* Wittr. et *Oe. amplum* Magn. & Wille tenere videtur.

Pithophora spec. aliæque algæ immixtæ sunt.

Brasilia, in fossa aquæ dulcis in insula Ilha dos Marinheiros prope oppidum Rio Grande civitatis Rio Grande do Sul 1892 (Exped. Regnell. Ima. Alg. no. 25); legit *G. A. Malme.*

Oedogonium Lindmanianum Wittrock, nov. spec.—Oe. dioicum nannandrium idiandrosporum: oogoniis singulis, suboboviformi-globosis vel subglobosis, poro foecundationis superiore apertis; oosporis oogonia fere complentibus, globosis vel subglobosis, echinis subuliformibus crebris; cellula suffultoria eadem forma ac cellulis vegetativis ceteris; androsporangiis 3–7 cellularibus; nannandribus subrectis, in cellulis suffultoriis sedentibus, spermogonio exteriore, unicellulari;

crassit. cell. veget. plant. femin.	25—30 μ,	altit.	1¾—4 plo majore:
" " " " androsp. fer.	22—25 "	"	2—4 plo "
" oogoniorum	46—57 "	"	46—57 μ;
" oosporarum (cum echin.)	45—56 "	"	45—54 " longitud.
	echinorum	"	2½–3 "
" androsporangiorum	22—24 μ,	altit.	17—27 "
" stipitis nannandrium	14—15 "	"	38—42 "
" spermogoniorum	8 "	"	16 "

Species ad *Oe. echinospermum* Al. Br. affinis. Differt imprimis poro foecundationis oogoniorum in parte eorum superiore (non mediana) sito. Oosporas submaturas aculeis destitutas sæpius vidimus.

America australis: Paraguay prope Paraguari 1893 (Exped. Regnell. Ima. Alg. no. 90); legit *C. A. M. Lindman.*

Oedogonium Wittrockianum Hirn, nov. spec.—Oe. dioicum nannandrium, idiandrosporum, oogoniis singulis, breviter oboviformi-globosis vel subglobosis, poro foecundationis in superiore parte oogonii sito apertis; oosporis globosis oogonia non plane complentibus, exosporio echinis conicis, spiraliter dispositis ornato. spiris 5–7, interdum anastomosantibus; cellulis suffultoriis eadem forma ac cellulis vegetativis ceteris; androsporangiis 1–5–?-cellularibus; nannandribus in cellulis suffultoriis sedentibus, stipite subrecto; antheridio 1–2 cellulari;

crassit.	cell. veget.	38—45 μ;	altit.	2—3 plo majore;
“	oogoniorum	63—73 “	“	68—75 μ;
“	oospor. (sine acul.)	53—63 “	“	55—67 “
“	cell. androsp.	36—38 “	“	11—26 “
“	stip. nannandr.	11—15 “	“	50—65 “
“	cell. antherid.	9—10 “	“	20—23 “

Species valde insignis, ad species echinosporas pertinens.

America australis: Paraguay ad Paraguari 1893 (Exped. Ima Regnelliana. Alg. no. 81); legit *G. A. Malme.*

Spirogyra Malmeana Hirn, nov. spec.—S. cellulis extremitatibus non replicatis, vegetativis diametro 2–5 plo longioribus; chromatophoris spiralibus ternis vel quaternis; cellulis sporiferis non tumidis, plerumque abbreviatis; zygosporis [positione ut in *Spirogyra variabili* (Hass.) Kütz.] ellipsoideis vel rotundatis, apicibus attenuatis, cellulas sporiferas longe non complentibus, membrana triplici præditis, exosporio hyalino, lævi, mesosporio irregulariter areolato, fusco, endosporio lævi; crass. cell. veget. 67–88 μ; crass. zygosp. 50–60 μ, long. zygosp. 70–83 μ.

Brasiliæ in rivulo, in aqua fere stagnante ad Cuyabá civit. Matto Grosso 1894 (Exped. Ima Regnell. Alg. no. 104); legit *G. A. Malme.*
—VEIT WITTROCK, *Stockholm.*

ALGÆ IN THE SOLFATARA AT POZZUOLI, ITALY.

DURING several visits to the somewhat active crater known as the Solfatara my attention was drawn to the great quantity of dark green slimy material found on the sides of the deep trench which leads to the principal outlet for steam, commonly known as the *Bocca*. A cursory examination of the green substance showed it to consist of

diatoms and other unicellular algæ in a thriving condition. I ascertained the temperature of the medium in which these organisms were growing and found it to range from 20° to 55° Centigrade. This is not remarkably high, but several circumstances in the environment seemed to me to be worthy of note.

The whole surface of the wall on which the algæ were flourishing was covered with freshly formed acid sulfate of aluminum. The steam which issues in large quantity from all the larger crevices in the rocks at a temperature of 100° Centigrade is highly charged with sulfur dioxide and is said to contain considerable traces of arsenic in some form. So much vapor of sulfur is also contained in the exhalations that quantities of sublimed sulfur are to be found crystallized in delicate needles about all the crevices or *fumaroles*. In all cases the mixed algæ are found growing up to the very orifices of these fissures, so that the plants are constantly bathed in the atmosphere just described and are constantly subjected to blasts of air and vapor at almost 100° Centigrade.

I have made no attempt to identify the several species of diatoms present. Professor W. G. Farlow has determined the organism which constitutes the great bulk of the deposit to be *Coccochloris Orsiniana* Meneghini.—J. Y. BERGEN, *Pozzuoli, Italy*.

EDITORIALS.

THE PROPOSITION to introduce into the Department of Agriculture at Washington a scientific chief seems to have set people to thinking about the generally unscientific organization of the scientific work supported by the United States government. In a communication to *Science*[1] Mr. Charles W. Dabney, Jr., discusses the need of a national department of science. Established as need appeared in connection with various departments, the scientific agencies of the general government have developed until they carry on work of great variety and extent, for which it appropriates annually nearly $8,000,000 and employs over 5000 men. A great amount of duplication now necessarily ensues from the fact that by natural extensions of the work in charge of one bureau it often overlaps that of another. Coordination seems to be impossible because the bureaus and divisions are parts of different departments, and therefore under the control of different officers. For example, there are three agencies carrying on land surveys, four prosecuting hydrographic work, and five independent chemical laboratories.

A National Scientific Department

THIS INDEPENDENCE means not only lack of coordination, but, generally, lack of cooperation. No one who is not familiar with the state of affairs in Washington understands how much jealousy and how little cooperation there is officially among these various bureaus and divisions. Apparently the more nearly related their work is, the less inclination there is to fraternize. This condition is not peculiar to Washington. It is only an exaggeration of the official jealousy that one too often finds between university departments that have "jest growed" instead of being adequately organized.

FORTUNATELY we have comparatively little of the personal bickering and even animosity which seems to be the rule in German scientific life, where no one is really satisfied until he has a *Feind*. Whether personal or official, all degrees of this feeling are phases of selfishness and arise from a too keen appreciation of one's own importance. It is fostered by official life, and in its extreme development becomes bureaucracy.

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[1] N. S. 5:73. 15 Ja 1897.

THE REORGANIZATION of government scientific work under a single department would be a long step in advance. It can be effected so gradually as not to interfere with the present efficiency. It is not advocated as a panacea. It would not remove jealousy, but it would minimize its evil effects. If proper accommodations for the department were provided, it would save money for investigations by concentrating routine work and enormously reducing the outlay for apparatus and fittings. It ought not to reduce the number of men engaged in investigation, but it might greatly reduce the number necessary for routine and office work. If reasonably administered such a department would not hamper but promote energetic development of research; it would not discourage but foster initiative in heads of divisions. In short the suggestion seems to have everything in its favor and nothing against it but pessimistic fears. If it were adopted as a policy by Congress and executed under the advice of the National Academy, we should expect to see the botanical work of the government promoted rather than retarded by the change.

Neglect of American Research

ANOTHER FLAGRANT case of ignorance of American research has just come to our notice. Indeed from the facts as they are at present known to us it would seem that it is not so much ignorance as a deliberate *ignoring* of American work. In the present number is a notice of the investigations of Paul and Krönig upon the effects of salts and acids in dilute solutions upon bacteria. The effects are due in such cases largely to electrolytic dissociation of the substances and action of the ions thus formed. Paul and Krönig reached the same results, *mutatis mutandis*, as those reached previously by Kahlenberg and True in their researches with beans, and confirmed by Heald with other seed plants. Kahlenberg and True were the pioneers in this line of investigation. They published their results with almost complete details in this journal for August last. Immediately upon its publication a copy of this paper was sent to Professor Ostwald, under whose direction Paul and Krönig were working. This must have been in his hands at least two months before their paper went to press, and probably longer.

Moreover, other separates, calling attention to the main results of their work, had been sent by Kahlenberg and True some months earlier. It is scarcely conceivable that Professor Ostwald, who reads and speaks English fluently, was ignorant of their work; and it is equally inconceivable that he should not call the attention of Paul and Krönig to it. Not the slightest allusion is made by them, however, even in a footnote or supplementary note, to indicate that there were any antecedent investigations of the same sort. To make it well nigh certain this was not ignorance but ignoring, it may be added that both Kahlenberg and True, neither of whom are personally known to Paul or Krönig, received from these gentlemen copies of separates of their paper. If the case is as it appears at present, it is not necessary for us to characterize such conduct. It declares itself at once unworthy of any man who lays any claim to the scientific spirit.

IN THIS SAME connection attention is called to the "open letter" from Dr. Davis, published in the present number, and which he courteously styles "oversight of American publications." Zukal's "oversight" of Dr. Thaxter's paper on Myxobacteriaceæ seems inexcusable under the circumstances, as does also that of Migula.

It is worth while perhaps to record a striking contrast to the neglect, not to say contempt, with which scientific work done outside the bounds of the German empire too frequently meets there. We have had occasion lately to examine with some care Ludwig's *Biologie der Pflanzen*, published about a year and a half ago, and it is a pleasure to observe the full recognition which he gives to investigations bearing upon ecology in all countries, even in England, America, and France. Apropos of the present discussion it may be added that Migula might have found in this book (dated 1895) a good account of Thaxter's Myxobacteriaceæ, illustrated by copies of the original figures from this journal.

The Tropical Laboratory

WHEN THE BOTANICAL GAZETTE first suggested the establishment of a laboratory in the American tropics, it referred to the well known establishment at Buitenzorg as an illustration of what was intended by the suggestion. This seems to have led to some misunderstanding on the part of botanists who pressed the illustration too far. By far the greater part of the Buitenzorg establishment has to do with economic problems, the facilities for research forming comparatively a small part of the whole establishment financially. It is certainly true that the extensive economic outlay represents an important part of the facilities for research, but such outlay is not essential to the inauguration of facilities for research in the tropics. The use of Buitenzorg as an illustration had reference only to equipment for such scientific work as has brought that station into botanical notice. The suggestion of the GAZETTE, and, so far as we know, the thought of the commission, does not contemplate an extensive establishment, with permanent director and staff, but merely an opportunity to work in tropical surroundings.

OPEN LETTERS.

BROMUS SECALINUS GERMINATING ON ICE.

To the Editors of the Botanical Gazette:—In the summer of 1895, G. H. True brought into the botanical laboratory some cakes of ice taken from the margin or top of the mass in the ice house, where the straw came in contact with them. Among the rubbish were a considerable number of grains of oats, chess, and perhaps seeds of other plants. Right in contact with the ice were kernels of chess with plumules half to three-fourths of an inch long and roots, some of which were very nearly two inches long. Numerous roots of chess in their growth had penetrated the clear ice for most of their length by thawing small holes with a diameter about three times that of the roots. Some of the roots curved more or less, but were easily removed.—W. J. BEAL, *Agricultural College, Mich.*

THE METRIC SYSTEM AND THE "ILLUSTRATED FLORA."

To the Editors of the Botanical Gazette:—Referring to your editorial in the February GAZETTE concerning the use of the metric system, in which you express your regret that it was not taken up in *Illustrated Flora*, I submit the following extracts from correspondence which will indicate our position in the matter.

Regents Office, Albany, N. Y., Feb. 18, 1897

Dear Professor Britton:

The enclosed seems to me a just criticism, unless you have some special reason for sticking by the old measure, instead of using the metric I admire so much your book that I was sorry to see you using the old measures.

Yours very truly,
MELVIL DEWEY.

New York City, Feb. 23, 1897

Dear Sir:

Dr. Britton has enclosed to me your favor of the 18th inst., with Professor Bessey's notes from the *Naturalist* on the metric system, and the omission of the *Illustrated Flora* to adopt it.

No doubt you are both quite right, looking at the subject from a scientific point of view alone. But the work, while intended to be as perfect as possible within the necessary limits, had to be arranged partly in reference to the general public. The work is planned not only for professors and students, but for plant lovers everywhere, and to stimulate interest in our flora among the people at large. The difficulties in comprehending the text, therefore, ought to be as few as possible. The adoption of the metric system would have added very sensibly to these difficulties, in matters of size, in which the unlearned are quite as much interested as the learned. Works depending on scientific patronage alone, and scientific publications by the government, may rightly adopt the metric notation; but the public at large, I think, can only be brought to it gradually, through the use of it in the primary schools.

Very truly yours,
ADDISON BROWN.

A comparative tabulation of the metric and English units will be printed in the third volume of *Illustrated Flora.*—N. L. BRITTON, *New York Botanical Garden.*

OVERSIGHT OF AMERICAN PUBLICATIONS.

To the Editors of the Botanical Gazette:—The attention of botanists should be called to the following somewhat glaring oversight of an important botanical paper. In 1892 Dr. Thaxter[1] published a paper entitled "On the Myxobacteriaceæ, a new order of Schizomycetes." One would have supposed that such a title would itself have attracted general attention. His paper is very complete, basing the new order of Schizomycetes upon the description of the structure and development of eight species in three genera, and is very well illustrated. This important contribution does not appear to have been noticed by Hugo Zukal,[2] who has recently founded a new order of Myxomycetes apparently upon a form identical with one of the species included in Dr. Thaxter's paper. As far as one may judge safely from a comparison of descriptions and figures, Zukal's *Myxobotrys variabilis* seems to be identical with *Chondromyces crocatus* B. & C. as described by Dr. Thaxter.

In respect to the structure of the plasmodium-like condition, together with the structure and development of the cystophores (Sporenträger) and cysts (Sporen) we find some important differences in the results obtained by these two investigators. Zukal finds granular matter in the substance of the plasmodium stage and some of it in the form of rods, but he considers them all to be microsomata. When the cystophores are developed the "rod-like microsomata disappear and in their places are found numerous long threads." Thaxter finds the pseudo-plasmodium to be made up of rod-like bodies whose general structure "together with their vegetative multiplication by fusion renders their schizomycetous nature as individuals a matter hardly to be doubted." When the fructification is to be developed the rods swarm around certain centers, and moving upwards collect to form the cysts attached to the cystophore, which is largely made up of hardened secretion. The rods in the cysts may retain their simple vegetative character or they may form spores (Myxococcus).

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[1] BOT. GAZETTE, **17**: 389–406. *pl. 22–25.* 1892.

[2] Myxobotrys variabilis Zuk. als Repräsentant einer neuen Myxomyceten-Ordnung. Ber. Deut. Bot. Gesell. **14**: 340. 1896.

Zukal thinks it probable that a motile stage similar to the myxamoeba stage of Myxomycetes follows the germination of the cysts. Thaxter has followed the germination of the cysts in detail. "The mass of rods thus freed begins at once to vegetate, the individuals dividing rapidly and entering upon a new period of activity."

Zukal, in spite of the simplicity of the plasmodium without nuclei and only made up of granular matter (microsomata), thinks the form of fructification sufficiently like some higher fungi (for example Botrytis) to hint a possible evolution of such forms from certain low types. Such evolution is to come about through epigenetic development embodying Lamarckian factors in an extreme form.

Thaxter sees in the structure and development of the rods undoubted schizomycete characters which clearly place the Myxobacteriaceæ in that group of plants. But while the rods are individuals they nevertheless act together in a remarkable manner, under certain conditions, to form a fructification resembling in superficial features certain filamentous fungi. The pseudo-plasmodium of the Myxobacteriaceæ has a certain similarity to the plasmodium of Myxomycetes but the cytological differences are enormous.

"In view of such important differences, the writer (Dr. Thaxter) would hesitate to assume even a remote genetic connection between two groups on a basis of resemblance which might well be purely accidental."

Perhaps in this connection it may not be out of place to inquire of Migula where he puts the Myxobacteriaceæ. No mention is made of the group in his account of the Schizomycetes to be found in *Die Natürliche Pflanzenfamilien.*—BRADLEY MOORE DAVIS, *University of Chicago.*

BIBLIOGRAPHY OF HYPOXIS.

To the Editors of the Botanical Gazette:—I have examined with interest the article of Mr. Holm in the February number of the GAZETTE on *Hypoxis hirsuta*, the original presentation of which I had the pleasure of listening to at the Biological Society of Washington a few months since. The article contains one feature which though essentially unimportant may, however, be misleading to some of your readers. I refer to the statement that the name *Ornithogalum hirsutum* of Linnaeus is a *nomen nudum*, that is, a name which was never really published and which therefore is without standing in nomenclature. The evidence that Linnaeus' name was not a *nomen nudum* is contained in Mr. Holm's article; indeed, one could scarcely have secured more conclusive evidence had that been the primary object of an exhaustive bibliographical research. It seems that before Linnaeus' work appeared, the plant he called *Ornithogalum hirsutum* had been described and in some cases figured by at least six different authors, and that four of these descriptions and two of the figures Linnaeus cited when he published the name. This constitutes as clear a case of actual publication as it is possible to have, and by a method which has been practiced by botanists everywhere and at all times. All the species in Linnaeus' *Species Plantarum* were published in essentially the same manner. If one were to publish a statement of the main facts in the life of George Washington, citing the dates of his birth and death, the battles in which he was engaged, and the official records of his actions while president, and should conclude "therefore, in view of these facts, it is evident that George Washington is a myth," he would not be drawing a more erroneous conclusion than Mr. Holm when he says that *Ornithogalum hirsutum* is a *nomen nudum.*

If *Ornithogalum hirsutum* L. is not a *nomen nudum*, not only is it permissible to retain the specific name when the plant is transferred to the genus Hypoxis, but under the rules it is mandatory to do so. It should be noted further that when Linnaeus in the second edition of the *Species Plantarum* placed this plant in Hypoxis, he cited first the *Ornithogalum hirsutum* of the earlier edition, followed by the same four citations he had used under that name, and no others.—FREDERICK V. COVILLE, *Washington, D. C.*

THE TROPICAL LABORATORY COMMISSION.

To the Editors of the Botanical Gazette:—The editorial reference to the finality of the decision of the tropical laboratory commission in the GAZETTE for February renders it proper to say that the commission is most willingly amenable to advice and suggestions and will welcome any assistance which will enable it to perform the duties it has undertaken, to the best advantage of all botanical interests. It may prevent misconceptions of the status of the commission and of the proposed laboratory, however, to state that the commission is a technically independent body, and that its decisions and action are not subject to revision by any existing organization, botanical or otherwise.

The recent absence of the writer from his address and the extended delays in Atlantic mails will make it impossible to announce the foreign membership before the tour of exploration begins.

In the course of the correspondence concerning the matter, letters have been received from a large number of botanists who have visited equatorial America. The following extract from a letter from Professor Goebel is a fair index of opinion concerning the nature and value of the proposed station: . . . . "and without doubt it (the tropical laboratory) will be of the very greatest importance to the science, and will give a strong impulse to the study of botany in America. . . . . It appears to me particularly desirable that the laboratory should be placed near a botanical garden, because of the greater number of plant-forms available, besides the herbarium and library as well as the opportunities for experimental culture afforded. Furthermore, another important condition would be the location of the laboratory as near as possible to a primitive forest. This would be of especial importance in researches upon cryptogams. If at all possible the main station should be in the highlands, with a subsidiary laboratory in the lowlands or on the seashore for the study of algæ, and the vegetation of tropical plains."

Professor Goebel furthermore advocates the selection of a locality easily accessible, and central to other areas offering advantageous conditions for research and exploration. So far as the general factors are concerned, botanical opinion seems united on the above points and the general policy of the commission as outlined in previous communications.— D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

The Desmids.

ABOUT thirty years ago Professor Otto Nordstedt of Lund (Sweden) began to study the Desmidiaceæ. He has written some two dozen contributions to our knowledge of the group, among which should be mentioned that upon the fresh water algæ found by Mr. Berggren in New Zealand and Australia. No one is better fitted than Mr. Nordstedt to undertake the laborious task of preparing the fine volume devoted to the bibliography of the group[1] which has been so long the object of his studies. One has but to consult the citations of certain authors, such as Archer, Ehrenberg, West, Wolle, etc., to be surprised at the exactness of reference to small notices which can be found with difficulty even in the greatest libraries, and at the diligence which must have been necessary to discover them. In the midst of such a vast number of citations the occasional omission of small notes or announcements of no great importance is not surprising, and detracts nothing from the notable merit of the work. Among these omissions are noted AGASSIZ, L., The vegetable character of Xanthidium, *Proc. Am. Ass. Adv. Sci.* —:89–91. 1850; BENNETT, A. W., Movements of desmids, *Am. Nat.* **20**:379–380. 1886; HASTINGS, W. N., How to collect desmids, *Am. Micr. Jour.* **13**: 113–116. 1892, and *The Microscope* **12**:147. 1892; HITCHCOCK, C. H., Swarm spores of Closterium, *Am. Micr. Jour.* **3**:76–77. 1882; PETIT, P., Preserving conferva and desmids, *Jour. Roy. Micr. Soc.*, *Am. Micr. Jour.* **2**:75. 1881, and *Am. Jour. Micr.* **6**:137. 1881; TURNER, W B., Staining desmids, *The Microscope* **5**:275. 1885, Process for mounting desmids, *Jour. Roy. Micr. Soc.*, *Am. Micr. Jour.* **7**:58. 1886; almost all of which are cited in Miss Josephine E. Tilden's "A contribution to the bibliography of American algæ" (*Minn. Bot. Studies*, 1895). Not only are pamphlets and special notes included, but the larger works of Hassall, Delponte, Ralfs, Cooke, Kirchner, Wolle, and the reviewer are constantly cited with scrupulous exactness. The index, which the author is justified in calling "*locupletissimus*," deserves high praise, and will certainly be of great service to all students of Desmidiacæ. Dr. Nordstedt is to be congratulated upon the successful completion of this great work.—DE TONI.

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[1] NORDSTEDT, C. F. O.—Index Desmidiacearum citationibus locupletissimus atque bibliographia. [Opus subsidiis et ex aerario Regni Suecani et ex pecunia

The appearance of Nordstedt's Index is welcomed by all students of desmids as an exceedingly useful work. During his thirty years of work on the desmids the author has labored to keep up with the bibliography, and while the present index is not quite complete, bibliographers know how difficult a thing it is to have access to every article published upon a subject so much written about. The index is, however, approximately complete, and one can gain a good notion of its fullness from the fact that about 1200 titles are listed. Over twenty exsiccatæ are listed which contain desmids among other algæ, in some cases the desmid numbers being given. The index proper includes families, genera, species, subspecies, varieties, and forms, arranged alphabetically, and the citations under each are arranged in chronological order, giving abbreviated names of authors and titles of the work in which the species is mentioned, so that the entire literature of each species is indicated. Under each citation is indicated what the character of the reference to the species is, as description, observations or notes, measurements only, name only, description of zygospore, figure of zygospore, other illustrations cited by number and plate. In the index there are about 24,000 such citations (under Botrytis alone about 180). All names are included in the index which would be needed in a study of the synonymy. Following the usual addenda is a chronological list of genera, and an alphabetical list of species under the genera.—G. F. A.

The African flora.

THE flora of Africa has received lately a largely increased share of attention, and our taxonomic literature is being flooded with descriptions of African novelties and monographs of various groups. One of the most prominent names connected with the African flora is that of Dr. Welwitsch, who was commissioned by the Portuguese government to explore their African possessions, broadly known as the province of Angola. In 1853 this explorer began his work, and in the face of tremendous obstacles in the way of sickness, difficulty of travel, opposition of natives, etc., spent seven years in the most unremitting labor. His herbarium is undoubtedly the best and most extensive ever collected in tropical Africa. The riches of his collections were indicated from time to time through his own publications and those of the various monographers to whom he submitted material. Permission was obtained from the Portuguese government to take his collections "to England and other northern countries" for study, and to this study he devoted the rest of his life, his death occurring in 1872. His name is familiar to every botanist as the discoverer of Welwitschia, so elaborately described by Sir Joseph Hooker. His enthusiasm as a collector may be inferred from his sensations

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Regiæ Societatis scient. Holmiens. collatis editum.] 4to. pp. 310. Lundæ, typis Berlingianis, 1896. (Bornträger's, Berlin, S. W. M. 20.)

upon the discovery of this remarkable plant. It is said that "when he first realized the extraordinary character of the plant he had found, his sensations were so overwhelming that he could do nothing but kneel down on the burning soil and gaze at it, half in fear lest a touch should prove it a figment of the imagination."

It is estimated that he reached London with more than 5000 species of plants. The bibliography of the collection shows 28 titles under the name of Welwitsch, and 61 titles under other names. At his death Dr. Welwitsch directed that the study set of his plants should be offered to the British Museum for purchase. The Portuguese government, however, claimed all of the collections, and demanded their delivery. This was resisted by Mr. Carruthers, then in charge of the botanical collections of the Museum, and Mr. Justen, of the firm of Dulau & Co. A suit in chancery was the result, and after long delays a compromise was reached in 1875, by which the Portuguese government was declared entitled to the collection upon condition that they should give to the British Museum the best set, next after the study set, which was returned to Lisbon. Mr. W. P. Hiern was engaged to sort and separate the specimens, and this afterwards led to his being engaged to prepare a catalogue of this remarkable collection for publication. At this late day, therefore, the first part of this catalogue has appeared.[2] It contains a preface by Mr. George Murray, explaining the ownership of the collection and the conditions of publication; a sketch of the life and labors of Dr. Welwitsch; and an account of the dicotyledons through Rhizophoraceæ. It is the intention to complete the dicotyledons in Part II, and to include the remaining groups in a third and concluding part.

It is useless to go into the details of a book containing such a mass of descriptions and notes. New genera and species abound, and the full notes give a very adequate notion of the relation of species, genera, and families to the vegetation as a whole. It is to be hoped that this exceedingly important publication will be carried to a speedy and successful conclusion. —J. M. C.

Physiological wall charts.

THE growing attention to instruction in plant physiology, even to elementary courses therein, is showing itself in the production of means for illustrating such courses. It is not long since the series of wall charts by Frank and Tschirch appeared. They served a useful purpose for small lecture rooms, but were altogether too small for rooms of any considerable size. Another series, composed of 15 plates, has just been published under the direction of Dr. L. Errera, professor in the University of Brussels, and Dr. E. Laurent, professor in the State Agricultural Institute at Gembloux.[3]

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[2] HIERN, WILLIAM PHILIP.—Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853–61. Dicotyledons. Part I. 8vo. pp. xxvi + 336. London: Printed by order of the Trustees [British Museum]. 1896.

These plates are of the same size as the well-known charts of Kny. The figures are not so numerous on each plate as to make them too small for ordinary lecture room, such as those seating 100–150, but for large halls they would be too small. To obviate this difficulty the publisher has arranged to furnish lantern slides in colors for those desiring them instead of the plates. The illustrations have been drawn from photographs of actual experiments, and particular pains have been taken to show the condition at the beginning as well as at the end of the experiment. The drawings are well executed and the plates are in every way commendable.

In the accompanying text the authors have given a generally satisfactory account of the phenomena illustrated upon the plates. Though brief, these explanations are usually comprehensive and clearly stated. The 100 pages of quarto text with their 86 half-tone reproductions of many of the figures on the plates form therefore almost a text-book of physiology. The subjects treated and the corresponding plates are as follows: I, the chemical composition of the plant and nutrition by the roots; II, respiration; III, nutrition by the leaves; IV, transpiration; V, saprophytic and parasitic plants and fermentation; VI, VII, carnivorous plants (Drosera, Dionæa, and Nepenthes), and fixation of nitrogen by Leguminosæ; VIII, IX, growth of roots, etiolation, growth of stems in length and thickness; X, geotropism; XI, heliotropism; XII, XIII, twining and climbing plants; XIV, the movements of leaves and flowers; XV, the variability of species as illustrated by the races of cabbage.

If all copies are printed on thin paper, as is that sent for notice, the plates would require mounting before they could be used safely as wall charts in the laboratory or class room. This, however, would not add very much to the cost, and the price at which the set is sold is certainly very easonable.— C. R. B.

Grasses of North America.

SUCH is the title of Professor Beal's work whose second volume has just appeared,[4] almost ten years after the first. This volume is noteworthy as it is the first attempt to bring together in a handy book all the grasses north

[3] ERRERA, L. et LAURENT, E.—**Planches de physiologie végétale.** Quinze planches murales en couleurs. 70×85^{cm}. Texte descriptif français, et explication des planches en français, en allemand et en anglais. 4to. pp. 102. figs. 86. Bruxelles: Henri Lamertin, 20 rue du Marché au Bois. 1897. 50 francs.

[4] BEAL, W. J.—**Grasses of North America. Vol II. The grasses classified, described, and each genus illustrated, with chapters on their geographical distribution** and a bibliography. 8vo. pp. viii + 706. **New York: Henry Holt & Co. 1896.**

of Mexico, and includes also the Pringle and Palmer Mexican collections. To those of us who know of the professional duties of Professor Beal, this large volume comes with a measure of surprise. That he could find time to undertake, and had the persistence to continue the use of his fragments of time long enough to reach this result, speaks well for his devotion to the subject. The author has fully described in these pages 912 species, 809 of which are natives. About 160 new names occur, arising from various causes, forty of them being those of unpublished species, chiefly Mexican.

Analytical keys are quite a feature of this volume, the author doing all in his power to facilitate the work of identification. The usefulness of keys must be tested by a somewhat wide range of use, so that no statement of Professor Beal's success in this regard can be made in advance.

Taking into consideration the shifting of opinions certain to occur during an active period of ten years, the author must have found it very laborious to adapt his work to every new statement of view that investigation proved worthy. It is to be expected that agrostologists will discover numerous things to which exception may be taken, but the writer has discovered, through painful experience, that the making of a manual covering a large area, or a large number of groups, calls for such an immense amount of detail that many things are sure to escape notice until too late to remedy. Professor F. Lamson-Scribner[5] has called attention to some of these with such detail as to make his notice useful as a permanent appendix to the volume.

The book is a great boon to agrostologists, and will stimulate the study of a group neglected out of all proportion to its importance.—J. M. C.

A new text-book and dictionary.

It seems evident that the elementary text-book of botany still remains to be written. The great development of morphology has tended towards excluding from our texts the larger relations of plants. Such taxonomy as is presented is of the sterile, pigeon hole kind, singularly free from evolution, morphology, ecology, geographical distribution, or anything else that gives taxonomy significance. Any indication that an elementary presentation of botany should include a consideration of plants as holding a definite place in nature, as occurring in societies that are determined by many external factors, as bound together by various genetic relationships, as consisting of organs which have an evolutionary history, should be hailed as the promise of better things.

Mr. Willis has prepared a book[6] which should be so regarded. Its primary purpose was to provide a compact book which would contain a summary of useful and scientific information about the plants to be "met with in a botanical garden or museum, or in the field." The second volume carries out this idea, and is a regular plant dictionary, containing a vast fund of information concerning the morphology, taxonomy, ecology, economic value, etc., of plants, arranged in the alphabetical order of their Latin names. All of the classes, cohorts, and families are included, and several thousand genera, the more important divisions being treated fully. The second volume, however, necessitated the first, which is really a brief text-book. The topics treated, as well as the motive of their treatment is suggested by the subjects of the four chapters, which are as follows: outlines of the general morphology and natural history of phanerogams and ferns; variation, evolution, classification; forms of vegetation, geographical distribution of plants, etc.; economic botany. A cursory examination of the pages shows that the author has brought together the most recent views upon these various subjects, treating them in a broadly philosophical yet simple way. In the chapter upon forms of vegetation and geographical distribution the author has used the same method of treatment as that of Warming in his *Ecological plant geography*, but had developed it independently. From our point of view the first volume is more important than the more extensive and far more laborious second volume, for the latter is a compiled dictionary, exceedingly useful, but the former is a well presented suggestion of a more rational style of text-book. The work is one of the Cambridge Natural Science Manuals.—J. M. C.

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[5] Science 5: 62. 1897.

[6] WILLIS, J. C. A manual and dictionary of the flowering plants and ferns. 2 vols. 8vo. Vol. I, pp. xiv + 224. Vol. II, pp. xiii + 420. Cambridge: The University Press; London: C. J. Clay & Sons. 1897. 10*s.* 6*d.*

The physiology of reproduction.

REPRODUCTION may be reckoned as the last and highest of the life-phenomena of any organism, marking the climax of its development and often the beginning of its decline. It is no wonder, therefore, that reproduction has been much studied, and that classification is so largely based on its structures and phenomena. But most of this study has been devoted to an accumulation of facts regarding the morphology of the organs and the direct method of its accomplishment. Comparatively little is yet known of the physiology of reproduction, and almost nothing of the external conditions by which it is limited.

Using the lower organisms as a starting point, Dr. George Klebs, professor of botany in the University of Basel, has attempted to penetrate this "dark world of reproduction," as he calls it, and has succeeded, in the course of nine years of labor, in making some advance. This has been along the line of determining the conditions under which reproductive bodies, both spores and gametes, are formed.

Enough has been accomplished for the author to plan a work "Ueber die Fortpflanzungs-physiologie der niederen Organismen, der Protobionten," of which the volume before us[7] may be considered as a preliminary special part. This part is limited to a detailed account of the behavior of certain algæ and fungi under varied environment.

In order to study some of these problems it was necessary to develop the methods of obtaining pure cultures of algæ and maintaining them in vigor as well as purity, especially for those species which have no striking characteristics at certain stages by which they can be instantly identified. Both fluid and solid media can be used for cultures, and Klebs recommends that both methods be used simultaneously. As a nutritive medium fluid he finds Knop's the best. It consists of

4 parts calcium nitrate,
1 part magnesium sulfate,
1 part potassium nitrate,
1 part potassium phosphate.

In preparing it a concentrated solution (*B*) may be made of the last three salts, and another (*A*) of the first. A proper amount of *A* is to be added to *B* after dilution to the desired percentage. By this method only a small part of the insoluble calcium phosphate formed will be precipitated. Solutions containing 0.2 to 0.5 per cent. of salts were found most useful.

As solid media one may use either opaque or transparent materials. For the former sterilized sand or clay, wet with the nutritive solution, are excellent. For the latter Klebs, having discarded silicic acid, now uses agar-agar, prepared by soaking 0.5^{gm} agar-agar in 100^{ccm} of 0.2, 0.4, or even 1 per cent. nutritive solution, heating, filtering, and sterilizing. In making pure cultures of algæ it is necessary to use the same precautions as are required with bacteria and fungi.

It is impossible to go into the details of the experimentation. Klebs has studied various species of *Vaucheria*, *Hydrodictyon utriculatum*, *Protosiphon botryoides*, *Botrydium granulatum*, several species of *Spirogyra* and *Desmidiaceae*, *Œdogonium diplandrum*, *Ulothrix zonata*, *Hormidium nitens* and *H. flaccidum*, *Conferva minor*, *Bumilleria sicula* and *B. exilis*, *Stigeoclonium tenue*, *Draparnaldia glomerata*, *Chlamydomonas media*, *Hydrurus foetidus*, *Eurotium repens*, and *Mucor racemosus*. Each of these is the subject of a chapter in which the results of his extended experiments are set forth. To Vaucheria he devotes most attention as introducing the extent and methods of experimentation. Upon the sexual and non-sexual reproduction of these plants Klebs endeavored to determine the effect of such conditions as nutrition, moisture, light, temperature, chemical composition of the medium, oxygen, and flowing water.

It is easy to see that the determination of the effect of each factor, when two or more must necessarily operate, is not at all an easy problem. Of some the effect seemed to be direct; of others it was exceedingly complex, and it would be quite easy to quarrel with the analysis in some cases. With many species it became possible to produce the sex organs or the zoospores at will; and in some species even to produce male or female organs in predominance by furnishing appropriate conditions. The volume is a monument of painstaking experimentation, and, even though elaborate, by no means represents the amount of energy which has been expended upon the problems.

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[7] KLEBS, GEORGE.—Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. 8vo. pp. xviii + 544. *pl. 3. figs. 15.* Jena: Gustav Fischer. 1896. *M* 18.

We are promised the second part "somewhat later." It is to contain a general discussion of the physiology of reproduction, based upon the researches here set forth and upon the scattered statements to be found in literature. It will be welcome, and we sincerely hope that it may be doubly welcome because supplied with an index of its own, and also one for this volume which at present is wanting. It should be made a penal offense for a publisher to issue a book without a suitable index.—C. R. B.

The Laboulbeniaceæ.

We welcome with pleasure the magnificent monograph of Dr. Thaxter[8] upon the Laboulbeniaceæ. It is not probable that any group of fungi has been honored within recent years with such thorough and detailed study as have these forms. The Laboulbeniaceæ are parasitic fungi living upon the bodies of insects, chiefly Coleoptera and Diptera.

The paper describes and illustrates with 26 plates 152 species belonging to 28 genera, and of these less than 20 species bear the names of authors other than Dr. Thaxter. He may be said to have established this group as a very important family both in respect to its systematic position and because of peculiarities of structure and sexual reproduction that make it particularly interesting.

Dr. Thaxter has adopted a system of nomenclature such that the names of the twenty-five new genera have the same endings. The results are pleasing and the continuance of the system is greatly to be desired as new genera are added.

We also express the hope that Dr. Thaxter may be allowed to describe the new forms which may be expected to be found all over the world. There is every indication that the group will prove to be a large one and only by great care will it be kept free from the mass of synonyms that overwhelms so many groups of fungi.

The Laboulbeniaceæ are very remarkable forms in many respects. They are highly specialized parasites living under peculiar conditions attached to the bodies of active insects. But they are chiefly interesting because they are ascomycetes in which sexual organs are unquestionably present in the form of trichogynes that are fertilized by antherozoids produced in curious antheridia.

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[8] Thaxter, Roland.—Contribution towards a monograph of the Laboulbeniaceæ. Mem. Amer. Acad. Arts and Sci. **12**: 187–429. *pl. 1–26.* Dec. 1896.

The main body of the plant, termed the receptacle, is usually quite simple in structure. It consists of several cells and is attached by a disk-like base to the integument of the insect. This integument is pierced at the point of attachment, and the parasite probably draws much of its nourishment from the insect. However, there is no mycelium in the body of the host, and under the most favorable circumstances one sees only a few slight processes put forth from the basal cell of the receptacle. The hosts do not appear to be seriously affected by the presence of the parasite. On the top of the receptacle are found filamentous appendages of great importance systematically and structurally because they bear the antheridia. Lower down on the side of the receptacle is situated the procarp, a multicellular structure containing a carpogenic cell and bearing the trichogyne.

After fertilization the carpogenic cell divides several times, and from certain of the products are developed the asci. While the asci are being differentiated the sterile cells of the procarp are active in forming the wall of the perithecium. The latter is generally a flask-shaped receptacle, opening through a pore at the top, in many respects, resembling the cystocarp of certain Rhodophyceæ. The ascopores are usually discharged in pairs from the perithecium and insects are probably infected through bodily contact with one another. One usually finds the plants growing in groups close together, a habit of great importance as it makes more sure the possibility of fertilization. In certain peculiar diœcious species one of the spores of the pair is smaller than the other and develops into a small male plant at the side of the female which may be ten times as large as the former.

The antherozoids are very small bodies, frequently rod shaped, and are developed in peculiar flask shaped cells, the antheridia. The protoplasm lies in the bottom of the cell and the antherozoids are formed one after another and discharged through a constricted region into the neck of the flask. In some instances several cells discharge their antherozoids into a common cavity, and the structure is then termed a compound antheridium. Antherozoids may be observed in great numbers attached to trichogynes, but the cells are so small and the points of fusion so minute that observations upon the precise act of fertilization will be attended necessarily with the greatest difficulties.

The trichogyne may be simple or very much branched. It may be a single cell or a very elaborate multicellular structure. In its most complex form it resembles a dense bunch of delicate filaments because of the numerous forkings. The ends of the filaments may become spirally twisted.

The trichogyne is never directly attached to the carpogenic cell. In the simplest cases the two organs are separated from one another by a cell which may be called the trichophoric apparatus. When the trichogyne is multicellular the point where the antherozoid fuses may be far removed from the carpogenic cell. The form of carposporic reproduction is therefore of a type similar to that of many genera of Rhodophyceæ (Callithamnion, Spermothamnion, Griffithsia, etc.), *i. e.*, the stimulus of fertilization must be transferred through several cells before it reaches the carpogenic cell. It should be said that the cells of the trichogyne communicate with one another by strands of protoplasm, a fact also true of the cells of all other parts of these fungi and an interesting point of resemblance to the Rhodophyceæ. There is therefore open protoplasmic communication from the tips of the trichogyne to the carpogenic cell.

However, it should be noted that this fact by no means solves the problem of how fertilization is accomplished. Accepting the everywhere prevalent view that fertilization consists in the fusion of two sexual nuclei, we must imagine the nucleus of the antherozoid to pass the length of the trichogyne from cell to cell, finally fusing with the female nucleus of the carpogenic cell. Such a phenomenon, the writer believes, is entirely unknown in the plant or animal kingdom, and it is extremely difficult to conceive the mechanism by which a sex nucleus could pass through a series of nucleated cells. The high degree of specialization of the sexual organs indicates, however, that sexuality is in an advanced state of differentiation in these forms.

The discovery of such a remarkable sex process in the Laboulbeniaceæ is an important contribution to the rapidly accumulating mass of evidence proving sexuality to be present among the ascomycetes. The observations are of particular interest in connection with Stahl's discovery of a trichogyne in Collema. Nevertheless it is manifest that we are far from a solution of the problems presented by the carposporic type of reproduction in the ascomycetes, although it is equally plain that the difficulties are not to be swept aside by a denial of sexuality after the fashion of Brefeld and his followers.—B. M. D.

MINOR NOTICES.

THE EXAMINATION of a set of *Lichenes Boreali-Americani*, now having reached 140 numbers, shows that the authors, Clara E. Cummings, Thos. A. Williams, and A. B. Seymour, are distributing material of the highest quality and from widely different localities. The first set, known as *Decades of North American Lichens*, and containing 210 numbers, was begun in 1892. In 1894 the second set, known as *Lichenes Boreali-Americani*, was begun. It is to be hoped that the extensive distribution of these authentic sets will stimulate the study of a group to which too few botanists are giving serious attention. No effort to send out consecutively numbered sets has been made since Tuckerman's day. To make the distribution of the greatest value the active cooperation of botanists is necessary, as extensive collections from different parts of the country should be in the hands of the authors. The subscription price for each decade is seventy-five cents, which may be sent to Clara E. Cummings, Wellesley, Mass.—J. M. C.

IT APPEARS like a relic of the ancient artificial systems to separate an "arborescent flora" from the other plants of a country, but when the Division of Forestry prepares a work on nomenclature it has no choice in the matter. Mr. George B. Sudworth, dendrologist of the Division, has prepared an extensive bulletin[9] which presents the mass of synonymy that belongs to our arborescent plants and adds largely to it. It is coming to be apparent that laws of nomenclature, like most laws, are not so important as their interpretation, and that a code to be effective for uniformity must be followed up by rulings that will embrace the widest possible combination of conditions.

Mr. Sudworth also seeks to unify the popular names, so that when a western man calls upon New England for honey locust he will not get locust. Mr. Sudworth has been of great service in bringing together such a mass of references, a very necessary work, but one from which almost any botanist naturally shrinks. Whether he has associated these names properly or not in his synonymy remains for monographers to decide. The introduction of new varietal, specific, and generic names is the logical result of any such undertaking, but so far as they are expressions of individual judgment and not purely mechanical they do not lead to greater simplification of nomenclature. It is a question whether our knowledge of plants in general and their literature will ever be so complete that even the majority of changes can be mechanical. But these are thoughts suggested by the problem of nomenclature in general, and not by Mr. Sudworth's work in particular, which shows a large amount of painstaking labor, and is certainly a valuable contribution to the bibliography of our arborescent plants.—J. M. C.

THE REPORT of the Pennsylvania Forestry Commission[10] has recently appeared. The commission consisted of two members, Mr. Wm. F. Shunk, an engineer, who discusses the water sheds and waterflow of the state and the relation of forest cover thereto, and Dr. J. T. Rothrock, botanist, who is responsible for much the greater part of the volume. The commission was charged with the duty of making a preliminary survey of the forestry interests of the state, and it has been succeeded by a well organized department, with Dr. Rothrock in charge of forestry. The report has for its object

[9] SUDWORTH, GEORGE B.—Nomenclature of the arborescent flora of the United States. Bulletin 14, Division of Forestry, Department of Agriculture, pp. viii + 419. January 21, 1897.

[10] Report of the Department of Agriculture, Part II. Division of Forestry. 1895.

the education of the people upon the relation of forests to waterflow and to soil conservation, the intrinsic value of forest products, and the importance of forest cover as a public resource. The discussions of these matters are clear and convincing, and they are so simply worded as to be within the comprehension of every citizen. It is unfortunate, perhaps, that more complete data of existing forest areas, extent of forest fires and waste lands, are not furnished, but the time of the commission was limited, and all things considered the report is calculated to fulfill its purpose. From the standpoint of the trained botanist the report contains little that is new or of special value, but the teacher of botany can find here a good example of the simplified treatment of his subject. Dr. Rothrock's descriptions of the economic trees of Pennsylvania are given entirely in colloquial English, without recourse to technical terms, and in thus keeping constantly in mind the needs of his readers he proves himself a master of the art of popular instruction. As an instance of luminous treatment of a difficult group, his discussion of the oaks may be cited. There is a simple classification, an occasional forestal reference that no mere book learned botanist could have given, but which appeals strongly to men who know trees from the woodman's standpoint, and a setting forth of specific characteristics that is altogether praiseworthy. There is a lack of editing in several contributed articles that is unfortunate, in that it lowers the standard of the volume from the high plane of the compilers. The illustrations are numerous and noteworthy, since in themselves they tell the story of the forest and its enemies.—B. E. F.

DR. A. ENGLER has just published a study of the geographical distribution of the Rutaceæ with relation to their systematic arrangement.[11] The contribution furnishes excellent argument and example for the pursuit of all taxonomic investigation with reference both to phylogeny and distribution. More than twenty years ago Dr. Engler began his exhaustive study of the Rutaceæ and allied families, but scarcely a year before the appearance of this recent publication he had prepared the treatment of the group which appears in the *Pflanzenfamilien*. In his earliest work upon the family the author emphasized the presence of oil glands as a character of much taxonomic convenience, pointing out that upon the basis of flower parts they may not be separated easily from the nearly related Geraniaceae, Zygophyllaceae, Simarubaceae, Burseraceae, and Meliaceae. Taking in order the subfamilies Rutoideae, Toddalioideae, and Aurantioideae, and under each its further subdivisions, the chief portion of the paper is devoted to a treatment of distribution by genera, from which the following grouping by distribution is made: (1) groups, especially Rutoideae-Diosmeae, and Rutoideæ-

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[11] Ueber die geographische Verbreitung der Rutaceen im Verhältniss zu ihrer systematischen Gliederung. Verlag der Königl. Akademie der Wissenschaften, Berlin. 1896.

Boronieae, which display a wide range of nearly related forms of limited distribution; (2) groups, as Xanthoxyleae-Evodiinae in eastern Australia, and Xanthoxyleae-Decatropidinae in Mexico and West Indies, which show a considerable number of widely separated forms or genera confined to limited areas; (3) groups and genera possessing more or less numerous forms in widely separated localities; (4) single groups and genera of few forms which occur in widely separated regions; (5) certain isolated genera, as Spathelia, Chloroxylon, and Dictyoloma, whose derivation the author believes to have been from a stock distinct from that of the more widely distributed groups of Rutaceae. By means of color upon map outlines, three handsome plates, which accompany the text, graphically represent the distribution of particular genera, and by elucidating the text add greatly to the comfort of the reader.—J. G. C.

NOTES FOR STUDENTS.

THE ALMOST simultaneous announcement of the discovery of spermatozoids in *Ginkgo biloba*[12] and *Cycas revoluta*[13] is one of the most startling botanical announcements of recent years. The work of Ikeno upon *Cycas revoluta*, begun three years ago, attracted attention from his announcement of a distinct ventral canal cell,[14] the existence of which was in doubt. These various announcements, however, are very brief and are but preliminary to the full illustrated papers which will be awaited with great interest.

In the case of *Ginkgo biloba* Hirase has observed the following facts: The pollen grain consists of two prothallial cells and the tube cell, the latter developing a much branched tube, the branches of which spread out over the surface of the thin nucellus cap. The innermost of the two prothallial cells enlarges and divides to form the stalk and generative cells. The generative cell then divides and the two daughter cells form motile spermatozoids, instead of the customary non-motile male cells. The spermatozoids are egg shaped, $49 \times 82\mu$, and have a central nucleus completely surrounded by cytoplasm. The head consists of a three-coiled spiral with numerous cilia, and a pointed tail was also observed. Within the nucellus above the archegonia there is an abundant liquid, probably secreted by the archegonia, in which the spermatozoids were observed to swim about with a rotating motion.

In *Cycas revoluta* Ikeno obtained almost identical results. The spermatozoids are a little larger than those of Ginkgo and the head is a spiral with four turns bearing numerous cilia. The production in each pollen tube of two spermatozoids by the division of the generative cell was also confirmed. Ikeno's work was entirely upon fixed material, so that he was unable to follow the motion of the living spermatozoids as Hirase had done, but he is sure that the spermatozoids reach the egg by swimming, as at the time of fertilization a large amount of water was observed between the cap cells of the nucellus and the necks of the archegonia.

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[12] S. Hirase (Tokyo) in *Botanical Magazine*, Oct. 1896, and in *Bot. Central.* Jan. 14, 1897.

[13] S. Ikeno (Tokyo) in *Botanical Magazine*, Nov. 1896, and in *Bot. Central.* Dec. 30, 1896.

[14] Bot. Central. 33: 193. 1896.

This discovery of a close association of ginkgo and the cycads is but confirmatory of what has been long suspected, as the former is too exceptional among the conifers not to have attracted attention, and more than one morphologist has suggested that it was a small-leaved cycad, rather than an anomalous conifer. Such confirmation, however, while it would have been notable enough under ordinary circumstances, is far eclipsed in importance by the discovery of the association of siphonogamic and zoidiogamic fertilization. One of the most important barriers between pteridophytes and spermatophytes is thus broken down, and the transition to siphonogamic fertilization brought out with almost diagrammatic clearness. The further interesting fact is noted that in these two forms the pollen tube does not reach the archegonium, and hence motile spermatozoids are necessary. The general primitive character of these forms must be remembered, so that it need not be expected that such a condition of fertilization will be found extensively present among the gymnosperms.—J. M. C.

THE IMPORTANT OBSERVATIONS of Professor Harper on "The Development of the perithecium in *Sphærotheca Castagnei*"[15] have been supplemented and extended by his studies on the development of the perithecium of Erysiphe, which, together with further observations on Sphærotheca and on Ascobolus, form the subject of his more recent and very interesting paper, "Ueber das Verhalten der Kerne bei der Fruchtentwickelung einiger Ascomyceten."[16] After giving a brief summary of the literature relating to the sexuality of the ascomycetes, the writer reviews and extends his previously published account of the development of Sphærotheca, and then describes the corresponding phenomena observed in *Erysiphe communis*. In this genus, as in Sphærotheca, the perithecium originates from two branchlets, derived from different hyphæ, the one oogonial, the other antheridial. The tips of these branches become separated by septa to form each a terminal cell, the smaller (antheridium) applying itself closely to the larger (oogonium). As a result of the absorption of the intervening walls an open communication is then formed between these two cells through which the single nucleus of the antheridium makes its way into the oogonium, where it unites with the nucleus of the latter. The stalk cell which bears the oogonium then produces terminally a layer of branches which grow up around it, and presently between this layer and the oogonium or carpogonium at least one more layer is similarly produced, these layers by further growth and branching forming the resultant perithecial wall. The changes which take place in the oogonium differ in many respects from those which occur in Sphærotheca. The fusion nucleus divides repeatedly until there are from five to eight nuclei in the carpogonium, which has in the meantime become elongate and somewhat bent. Through the formation of transverse septa the latter organ then becomes converted into a series of superposed cells, each containing a single nucleus, except the penultimate, in which there are always more than one. This penultimate cell constitutes the ascogonium, which gives rise from all parts of its surface to ascogenic hyphæ. The ascogenic hyphæ then divide to two or three cells, and of these one, which is always intercalary, grows directly to form the ascus, five to eight of which eventually mature. The cells of the ascogenic hyphæ which are destined to form asci are distinguished by the fact that they contain two nuclei that ultimately unite to form a fusion nucleus which presently divides to form the ascospores.

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[15] Berichte d. Deutsch. Bot. Gesell. **13**: 67. 1895.

[16] Prings. Jahrb. f. wiss. Bot. **29**: 655–685. 1896.

The author, in addition to further interesting observations on Erysiphe that cannot here be mentioned, also gives an account of the development of Ascobolus; which, however, from the fact that no very early stages were observed, leaves the question as to the presence or absence of a sexual union in this instance still an open one. The formation of a fusion nucleus in the young ascus was determined, and interesting details are presented concerning the structure and nuclear characters of the carpogonium. The paper, which is clearly written and refreshingly concise, closes with a suggestive discussion and comparison of the phenomena above mentioned in connection with some of the more recent theories respecting the sexuality of the higher fungi, and it need only be noted here that the author is not inclined to admit the sexual nature of the nuclear fusions which immediately precede spore formation in so many cases among these plants.—R. T.

THE INTERRELATIONS of the different sciences is well illustrated in the advance that has been made in our knowledge of the action of chemical substances on living protoplasm from the physico-chemical standpoint. From this point of view, Paul and Krönig[17] have contributed an exceedingly valuable article on the effect of different chemicals upon plant life. The general trend of the paper follows the lines that have recently been developed by Kahlenberg and True,[18] although no reference is made to the pioneer work done by these American investigators who worked upon green plants.

As the bacterial spore is not affected by plasmolysis Paul and Krönig find these structures better adapted to their purpose than the vegetating cells. Exposure of the bacteria to the action of the desired chemical is made by immersing in a solution of definite strength small garnets of uniform size that have previously been coated with a film of an infected solution. After a definite exposure, these are removed and replaced in nutrient media. The intensity of chemical action is noted by the development of the cultures.

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[17] Zeit. f. phys. Chemie **21**: 414. 1896.

[18] BOT. GAZ. **22**: 81. 1896.

The explanations that have been offered to account for the action of different chemicals upon living matter have been far from satisfactory. The whole subject is in a chaotic state, and while we possess sufficient empirical knowledge to enable us to arrange chemical substances in order of their effectiveness, no underlying principle has yet been brought to light that coordinates the enormous mass of facts that have been collected within recent years. While in strong solutions it is undoubtedly true that the destructive effect of certain chemical substances is due to their corrosive or oxidizing properties, whereby the protoplasm is actually destroyed, there can no longer be any doubt, from the results here obtained, that in dilute solutions, the action of the molecule is largely dependent upon the dissociation that it undergoes in the solution. Paul and Krönig find by using solvents such as ether and absolute alcohol that do not permit dissociation of the salt into its constituent ions, that its toxic effect is slight; whereas if the salt is separated into the basic and acid ions, even in part, as in dilute watery solutions, its action is much more marked. In a number of instances where the disinfecting effect of a salt is diminished by the addition of other substances, as $HgCl_2$ in contact with NaCl, they find the explanation of these results in the formation of complex ions in which the actively disinfecting ion is not free to exert its toxic effect. Thus, while silver and gold salts, as $AgNO_3$ and $HAuCl_4$ are powerful germicides, their action is greatly weakened when mixed with KCy.

The remarkable observation made by Scheurlen[19] that the effect of phenol is increased by adding such a salt as NaCl, they are able to confirm, but, in the light of this theory, they are unable to explain it. The application of this new theory to the action of chemical substances on bacteria is most suggestive as it brings a large mass of isolated facts under the operation of a general law.—H. L. RUSSELL.

THE ORGANIC NUTRITION of green plants has just been considered by Th. Bokorny.[20] He suggests that the ability of fungi to use organic food is not to be considered peculiar to them. We know that many cells in a green plant are always nourished with organic substances. Only in the leaves and a small part of the stem is chlorophyll present and only in these parts can CO_2

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[19] Die Bedeutung d. Molekularzustandes d. wassergelösten Desinfektionsmittel f. ihren Wirkungswert. Strassburg, 1895.

[20] Ueber die organische Ernährung grüner Pflanzen und ihre Bedeutung in der Natur. Biologisches Centralbl. 17: 1–20, 33–48. 1897.

be assimilated. All other cells of the plant must use as food such substances as sugar, asparagin and amides from which to construct cellulose, starch and protoplasm.

A large number of cultures were made to determine whether plants could use organic food. Weak solutions of various acids, alcohols, aldehydes, ketones and amido-compounds were employed. Since free acids are always poisonous they were neutralized with milk of lime. Except where the compounds employed were active poisons, almost none failed to be, to some extent, assimilated.

The author gives in condensed tabular form the results of his own work and that of other investigators. Some organic compounds can be used only in presence of light and assimilation is aided by light in all cases. Such substances as peptone, glycerin, asparagin and sugar in which fungi grow luxuriantly are also suitable as food for green plants.

Of great interest is the successful artificial culture of green plants with amido compounds such as asparagin, leucin, tyrosin, glycocol, etc., since these products of proteid decomposition are often present naturally in the soil. It has been definitely shown that asparagin can furnish nitrogen for the formation of proteids and in some cases plants thrive better if provided in this way than when obliged to obtain nitrogen from nitrates of the alkali metals.

The significance of the use by plants of organic matter is not to be underrated. Plants thrive better when furnished with such food. Decomposition products are taken up by plants and thus removed from the soil. Rivers, polluted with sewage, undergo, by means of the vegetation they contain, a continual self purification.

Many carbon compounds can be assimilated by green plants in the dark. A preliminary splitting of the molecule into CO_2 and H_2O does not occur, for the assimilation of CO_2 takes place only in the light. The author is inclined to agree with the hypothesis of O. Loew that from all organic substances used as food the molecular group CHOH is produced, and either with the aid of ammonia proteids are formed, or without such assistance carbohydrates are developed. In support of this theory he adduces the fact, proven by experiment, that such compounds as contain the group CHOH ready made are most readily assimilated. Further investigation on this point is very much needed.— FRANCIS RAMALEY, *University of Minnesota.*

NEWS.

Dr. Carl Mez has been called to a professorship of botany at the University of Breslau.

The *Kew Bulletin* for January contains a complete list of Kew publications from 1841 to 1895 inclusive.

The death of Professor Dr. Alexander Batalin, director of the Imperial Botanical Garden at St. Petersburgh, is announced.

Dr. Wladislaw Rothert, *privat docent*, has been called to the assistant professorship of botany in the University of Kazan.

Professor L. H. Pammel has distributed his first fascicle of Iowa plants. The others will be distributed as soon as the material is ready.

Dr. Constantin von Ettingshausen, until 1896 professor of botany and paleontology in the University of Graz, died on the first of February.

During the year 1896 the Royal Gardens at Kew were visited by 1,396,875 persons, the largest attendance upon any one day being 86,399 on May 25.

A new botanical text-book by Dr. W. A. Setchell is announced by The Macmillan Company as in press, bearing the title *Laboratory Practice for Beginners in Botany.*

Miss Bertha Stoneman, who received the degree of Doctor of Science at Cornell University last June, is continuing her investigations on fungi in the botanical department of the same institution.

The Macmillan Company announces that the Bonn text-book of botany translated by Dr. H. C. Porter of the University of Pennsylvania, revised and edited by A. C. Seward, will be ready in March.

M. Ed. Bonnet has concluded that *Phaseolus vulgaris* was unknown in the Old World before the discovery of America. His discussion appears in several recent numbers of the *Jour. de Botanique.*

The Directors of the Biltmore Herbarium have sent out a list of about 500 plants for exchange, mostly collected in western North Carolina, but containing quite a number of rare and interesting forms. Correspondence is to be addressed to the curator, C. D. Beadle, Biltmore. N. C.

THE "Reale Istituto Lombardo di Scienzi e Lettere" of Milan has awarded a prize of *M* 800 to our associate, Professor Dr. J. B. DeToni, for a treatise upon the life and works of Leonardo da Vinci.

THE EDITION of *Uredineæ Americanæ Exsiccatæ*, prepared by Mr. M. A. Carleton, one fascicle only having been issued, has been exhausted. Owing to pressure of other work the author is obliged to permanently discontinue the series.

"THE FERN-COLLECTOR'S HANDBOOK AND HERBARIUM," by Miss S. F. Price, is announced for speedy publication by Messrs. Henry Holt & Co. It is intended to be a popular work, and will contain seventy-two large plates, most of them life size.

PROFESSOR D. P. PENHALLOW calls attention to the following correction that should be made in his paper on Myelopteris, which was published in the BOTANICAL GAZETTE for January last: "resin canal" should be changed to "gum canal" on page 28 last line, and on page 29 line 16.

MR. AUG. SAUPE, R. A., sculptor, prepared a death mask of the late Baron Ferdinand von Müller. Copies of this may be obtained. Mr. Saupe is engaged in modeling a life-size bust and a medallion, copies of which will also be for sale. His address is 85 Coppin street, Richmond, Victoria, Australia.

THE BOOK entitled *The Botanists of Philadelphia and their Work*, whose preparation by Dr. John W. Harshberger, of the University of Pennsylvania, was announced about a year ago, is now completed and lies in manuscript. It will contain when printed about 500 pages of printed matter and fifty full-page plates.

DR. PAUL TAUBERT, of the Royal Botanical Museum of Berlin, who has been engaged in botanical exploration of the Amazon region of northern Brazil for a year past, fell a victim to the yellow fever at Manaos on the first of January last. He was a special student of the Leguminosae, which group he elaborated for Engler and Prantl's *Natürlichen Pflanzenfamilien*.

A NEW GERMAN WEEKLY, *Die Umschau*, began publication January 1 of this year, under the editorship of Dr. J. H. Bechhold. It has a broad field as the chronicler of the progress in science, industry, literature, and art. Among the collaborators, Professor Dr. Magnus and privat-docent Dr. A. Nestler are announced for the science of botany. The yearly subscription is *M* 10.

WE ARE INFORMED that the extensive herbarium of the late Dr. J. F. Joor is offered for sale. The collection is the result of twenty years of the most industrious work, principally in Texas, though frequent trips were made along the gulf coast of Mississippi and into the swamp regions of Louisiana. Details may be learned by addressing Mrs. Joor, 6063 Laurel street, New Orleans.

THE SILVER MEDAL of the Veitch Memorial Fund of England has been presented to Professor L. H. Bailey, "in recognition of his efforts, by means of his lectures and his writings, to place the cultivation of plants on a scientific basis, to promote the extension of horticultural education, and by numerous trials and experiments, to improve and render more productive plants grown for economic purposes."

THE GAMOPETALÆ of Gray's *Synoptical Flora* were issued by the Smithsonian Institution as "Miscellaneous Collection no. 591." The stock having been exhausted, at the request of Mr. F. V. Coville the institution has issued recently 150 additional copies which are now ready for distribution. The price has been fixed at $2.50, and those desirous of purchasing the work should send this amount by money order or draft to the Smithsonian Institution, Washington, D. C.

THE FIELD COLUMBIAN MUSEUM of Chicago has been so fortunate as to procure from the widow of Dr. Arthur Schott his complete personal herbarium, containing his collections in Campeche, Tabasco, Upper Mexico, Mexican Boundary Survey, Hungary. The nine hundred or more Yucatan plants will prove of great value to Dr. Millspaugh, the Curator of Botany, in his interesting series of "Contributions to the Flora of Yucatan." We are glad to note that the Muesum is alive to the occasions presented to increase the utility and status of its Botanical Department.

AT THE COMING Toronto meeting of the British Association, August 18 to 25, members of the American Association will be admitted as members. Section K (Botany) will hold its sessions under the presidency of Professor H. Marshall Ward. It is believed that the meeting will be very largely of an international character, and it is hoped that American botanists will contribute to that result both by their presence and their papers. Detailed information may be obtained by addressing Professor E. C. Jeffrey, University of Toronto, Secretary of Section K.

MR. JAMES LLOYD, author of *Flore de l'Ouest de la France*, who died May 10, 1896, left his fortune and collection to the city of Angers. Aside from careful directions as to the care and autonomy of the collections, it was directed that a curator be appointed by the mayor of the city, to be selected from three candidates proposed by the Botanical Society of France. Provision is made for the salary of the curator and for his prosecution of the work on the flora of the region in which Mr. Lloyd was interested. The Botanical Society is now asking for applicants from which they may select three, all applications to be made on or before March 15. Mr. Lloyd expressed his preference that this position be given, not to university men, but to some "humble botanist, a lover of nature."

MR. LORENZO N. JOHNSON died at Boulder, Colorado, February 27, at the age of 34. He had been in Colorado for a year, hoping to recover from the pulmonary trouble which caused his death. He was an instructor in the University of Michigan for three and a half years, being especially interested in the fresh water algæ, and having published several papers upon Desmidiaceæ. He collected the fungi of Ann Arbor so assidiously during his connection with the university as to make their collection of indigenous species one of the best in the west. His aptitude for systematic and descriptive work must have insured a scientific career of unusual attainment. Aside from his connection with the University of Michigan he was engaged for several summers at Cold Spring Harbor, where he had charge of the instruction in botany.

AT THE LAST MEETING of the Botanical Seminar of the University of Nebraska the following papers were presented: The periodicity of flowering, by Mr. Clements; Herbaceous vegetation forms, by Mr. Pound; The karyology of the ascomycetes (a review), by Mr. Shear; Organogeny of the genus Prunus, by Mr. Bell. The Seminar has had a semester of unusual enthusiasm and activity. Since the beginning of the college year there have been four public meetings in which twelve papers have been read; and symposia upon the laboratory method, phytogeography, and systematic mycology have been held. For the present semester six meetings have been arranged for, at which eleven papers will be presented; and symposia will be held upon histogenesis and physiology. Dr. Trelease will deliver the annual address, his subject being "The description of a species."

A SECOND BULLETIN of the New York Botanical Garden gives additional information as to plans. The many problems that have presented themselves for solution are discussed. The museum building, with a frontage of 304 feet, with two equal lateral wings whose total completed length will be about 200 feet, will give ample space for collections and laboratories. The allotment of the grounds is of interest; buildings, with decorative approaches and surroundings, about 25 acres; pines and other coniferous trees (90 to 100 species), 30 acres; deciduous trees (about 275 species), 70 acres; natural forest, mostly undisturbed, 65 acres; shrubs and small trees, 15 acres; herbaceous grounds for scientific arrangement, 8 acres; bog garden, 5 acres; lakes and ponds (exclusive of the Bronx), 6 acres; meadows, 10 acres; besides various provisions for aquatics, vines, rockeries, etc. The bulletin also contains Dr. Britton's address on "Botanical Gardens."

The MACMILLAN COMPANY announces that the compilation of an *Encyclopedia of American Horticulture* has been begun under the editorial supervision of Professor L. H. Bailey, of the Cornell University. There has never been a really good and adequate presentation of American horticulture, and this book proposes to make good the want. It is to cover horticulture in its widest sense, pomology, floriculture, vegetable gardening, greenhouse matters, ornamental gardening, the botany of cultivated plants, and the like. The work will consist of signed articles by specialists, profusely illustrated by engravings made expressly for it. The articles will be arranged alphabetically, and it is expected that the number of entries will be about six thousand, comprised in three large volumes dated 1900. The earnest cooperation of every student of horticultural pursuits and every lover of rural life is solicited, in order that the work may be worthy of the opening of the twentieth century.

THE VERMONT Botanical Club was organized two years ago, and now has sixty active members. It meets twice yearly, in summer for a field meeting, in winter for the reading of papers. The second annual meeting was held in Burlington, February 5 and 6, at which twenty papers were read. A paper of special interest was that by Mr. C. G. Pringle, which was a sketch of his botanical explorations in the state, chiefly between 1873 and 1880. The paper is published in full in the *Burlington Daily Free Press* of February 9, and is really a valuable autobiographical sketch which many botanists would be glad to possess. The results of Mr. Pringle's early collections among the mountains of Vermont are well known, and their lasting evidence is found in numerous herbaria. It is a great pleasure, however, to read this more vivid account of his most notable discoveries, and to catch the flavor of his rare experiences on Willoughby mountain and in Smuggler's notch, and in the other boreal regions whose rare plants he so successfully brought to light. This prince of collectors modestly remarks that he "was only the first available man" for such work, but the recipients of his plants will contend that he was specially fitted to it.

The club is actively prosecuting a botanical survey of the state, and intends to publish a revised "Flora of Vermont" within two years. The officers for the ensuing year are: Ezra Brainerd, President of Middlebury College, President; Cyrus G. Pringle, Charlotte, Vice President; and L. R. Jones, University of Vermont, Secretary.

THE REPORT of the Director of The Missouri Botanical Garden for 1896 contains much interesting information in reference to present equipment and future plans. Many causes have combined to compel the trustees to proceed slowly, so that those things which seem necessary to botanists, considering opportunities for research alone, could not be provided rapidly. The herbarium is estimated to contain about 258,629 specimens, of which 97,800 belong to the Engelmann herbarium, and 61,246 to the Bernhardi herbarium The library contains 23,257 books and pamphlets, and 165,969 index cards. A very full statement is made of the provision for garden pupils, their course of study, and the results. Probably the greatest general interest of the report will be found in the full setting forth of the plans for the future. The three principal objects to be kept in view are "beauty, instructiveness, and adaptability to research." In the development of the ground and plant houses the suggested lines are "for florists' forms, for horticulture, for educational purposes, for investigation." It is proposed that in the smaller plantation, devoted to the flora of the United States, the arrangement shall be based upon the *Genera Plantarum* of Bentham and Hooker, as the one most familiar to American botanists, and that in the general synopsis of the larger tract the sequence of Engler and Prantl shall be used, as better expressing the phylogeny of plant groups. The Director proposes that for a few years all available income shall be devoted to the development of the North American synoptical plantation. Aside from the proposed planting, however, the attention of the trustees is called to the further need of facilities for research in the way of library, collections, enlarged laboratory space and facilities, and endowment. Much has been done already in the way of a strong development of the library and herbarium, as visiting and exchanging botanists have occasion to know, but the thought of the Director extends much further, as the following sentence will testify: "I hope to live to see the income of the Garden so ample that it shall claim among its regular employees men recognized as the equal of any in the country, if not in the world, in horticulture, vegetable physiology, morphology, paleobotany, phanerogams, pteridophytes, bryophytes, fungi, algæ, and lichens."

In this same connection it should be noted that candidates for the Doctor's degree in Washington University may elect research work in botany as their major, which puts at their disposal all the resources of the Garden, with Dr. Trelease to direct them. In the account of opportunities for research work in botany in American institutions published in the BOTANICAL GAZETTE for February the Missouri Botanic Garden was omitted, as for convenience only those institutions were considered which gave the Doctor's degree. The arrangement between Washington University and the Garden was overlooked, which very properly would have entitled the Garden and its equipment to representation.

A CIRCULAR of information has been received concerning the scientific division of the Allgemeine Gartenbau-Ausstellung to be opened in Hamburg in May, and to continue until September 1897. Certain features of this exhibition should attract the attention of botanists. The exhibits of the scientific division are divided into such groups as diseases of cultivated plants, animal and vegetable parasites injurious to agricultural products, plants and animals beneficial to agriculture, collections of plants and plant-parts made from a morphological or biological standpoint, results of scientific experiments upon pollination, etc. The exhibits will possess especial interest for physiologists and pathologists, to stimulate whose best endeavor numerous special awards are to be made, in addition to the usual medals of honor. For this purpose the government has provided 20,000 francs. In the field of botany the following prizes may be noted:

Desideratum. Series no. 222. Researches leading to the solution of one or other of the following questions: (1) To give a method of isolating a bacterial toxin in a state of complete purity so as to determine its chemical formula, etc. (2) To indicate a practical process for the preparation of antitoxins *in vitro*, by the electric current or any other physical or chemical agent applied to bacterial cultures. (3) To present a process permitting the extraction from antitoxic serums, the products of secretion, or liquids possessing the same properties, the body or bodies to which they owe their activity. (4) To investigate whether an antistreptococcic serum obtained from a single variety of streptococcus is efficacious against all the varieties of streptococcus pathogenic for man, or whether it is active against a certain number of these varieties. (5) Does the anti-diphtheritic serum possess, besides its antitoxic power (*i. e.*, of neutralizing the toxin), a power over the leucocytes, in virtue of which it stimulates them to destroy the bacilli of diphtheria? Is the measure of one power that of the other also? Prize 900 francs, to be divided into two.

Desideratum. Series no. 224. New researches tending to the solution of one of the two following questions: (1) A method of preserving for collections the bacterial cultures on solid media with their characters. (2) A process for the preservation of specimens of perishable plants for exhibition in museums. The objects must retain their natural aspect and colors, and the process must not be costly. Specimens are to be presented in proof. Prize 600 francs, to be divided if occasion requires.

Desideratum. Series no. 225. New researches on the organs of living beings by means of an apparatus using the X-rays. Prize 1000 francs.

Concours. Series no. 240. (B) The construction of a solid clinostat, not to exceed in price 500 francs, permitting the rotation on an axis in any direction of a potted plant having a maximum weight of six kilos, or of several plants whose total maximum weight is the same. (C) Exhibit an apparatus (or several) for the demonstration to a number of auditors of the process of cell division. Prize 300 francs.

Desideratum. Series no. 375. (B) To present a good manual of the infectious and organic diseases of forest trees, indicating especially the nature of the disease and the proper remedies; and with the manual a collection of specimens as complete as possible showing the diseases. Prize 300 francs.

AT THE MEETING of the Academy of Science of St. Louis on the evening of February 1, 1897, Professor L. H. Pammel read a paper embodying ecological notes on some Colorado plants, observing that botanists who have studied the Rocky mountain flora have frequently commented on the interest attached to the plants from an ecological standpoint, but most perplexing to the systematist. It is not strange that this should be the case, since there are great differences in altitude and soil and the relative humidity of the air varies greatly. This is a most prominent factor in the development of plant life. A cursory glance at the plains flora of eastern Colorado shows that there are representatives of a flora common from Texas to British America, and east to Indiana. We should not for a moment suppose that the species are identical in structure, since the conditions under which they occur are so different. Attention was called to the great abundance of plants disseminated by the wind, as *Cycloloma*, *Salsola*, *Solanum rostratum*, *Populus*, *Cercocarpus*, "fire-weeds" (*Epilobium spicatum* and *Arnica cordifolia*), *Hordeum jubatum*, *Elymus Sitanion*, etc. Plant migration may be studied to better advantage in the irrigated districts of the west than elsewhere, partly because the water carries many seeds and fruits in a mechanical way and partly because the soil is very favorable for the development of plants. Instances were cited where several foreign weeds are becoming abundant, as *Tragapogon porrifolius* and *Lactuca Scariola*. The latter, known as an introduced plant for more than a quarter of a century, is common at an altitude of 7500 feet in Clear creek cañon. Once having become acclimated, it is easy to see how prickly lettuce is widely disseminated.

Collectors appreciate the great importance of giving more attention to conditions under which plants thrive, such as phases of development, soil, climate, and altitudinal distribution. Structures of plants are produced to meet certain conditions. Under extreme conditions protective devices are more pronounced. In discussing some of the plants, Warming's classification into hydrophytes, xerophytes, halophytes, and mesophytes, was adopted. The mesophytes of eastern Iowa were compared with some of the xerophytes of western Iowa, such as *Yucca angustifolia*, *Mentzelia ornata*, *Liatris punctata*, etc. These increase in numbers in western Nebraska, and attain a maximum development in northern Colorado. In the foothills and mountains the mesophytes constitute a large class, although xerophytes are common in the dry, open, sunny places. The photosynthetic system is reduced to guard against excessive transpiration which would otherwise take place at high altitudes. The thick rootstock of alpine plants in dry, open places is an admirable protection against drouth and cold. In cañons where snow remains on the ground, plants do not need this protection. Halophytes are not numerous in species and genera. Hydrophytes are abundant at higher altitudes, where they occur in marshes and along streams.

At the meeting for February 15, Dr. Trelease exhibited "hair balls" removed from the stomach of a bull in Mexico, and showed that they were composed of the pointed barbed bristles of some species of prickly pear upon which the animal had fed.

At the meeting for March 1, Mr. William H. Rush presented a demonstration of the formation of carbon dioxide and alcohol as a result of the intramolecular respiration of seeds and other vegetable structures in an atmosphere containing no free oxygen. The theory of the dissolution and reconstruction of the living nitrogenous molecules was explained in connection with the experiments, and the different behavior of these molecules when supplied with or deprived of free oxygen, was indicated.

Mr. H. von Schrenk briefly described certain œdematous enlargements which he had observed at the beginning of the present winter near the root tips of specimens of *Salix nigra* growing along the edge of a body of water. The speaker compared these with the œdemata of tomato leaves and apple twigs, which were studied some years since at Cornell University.

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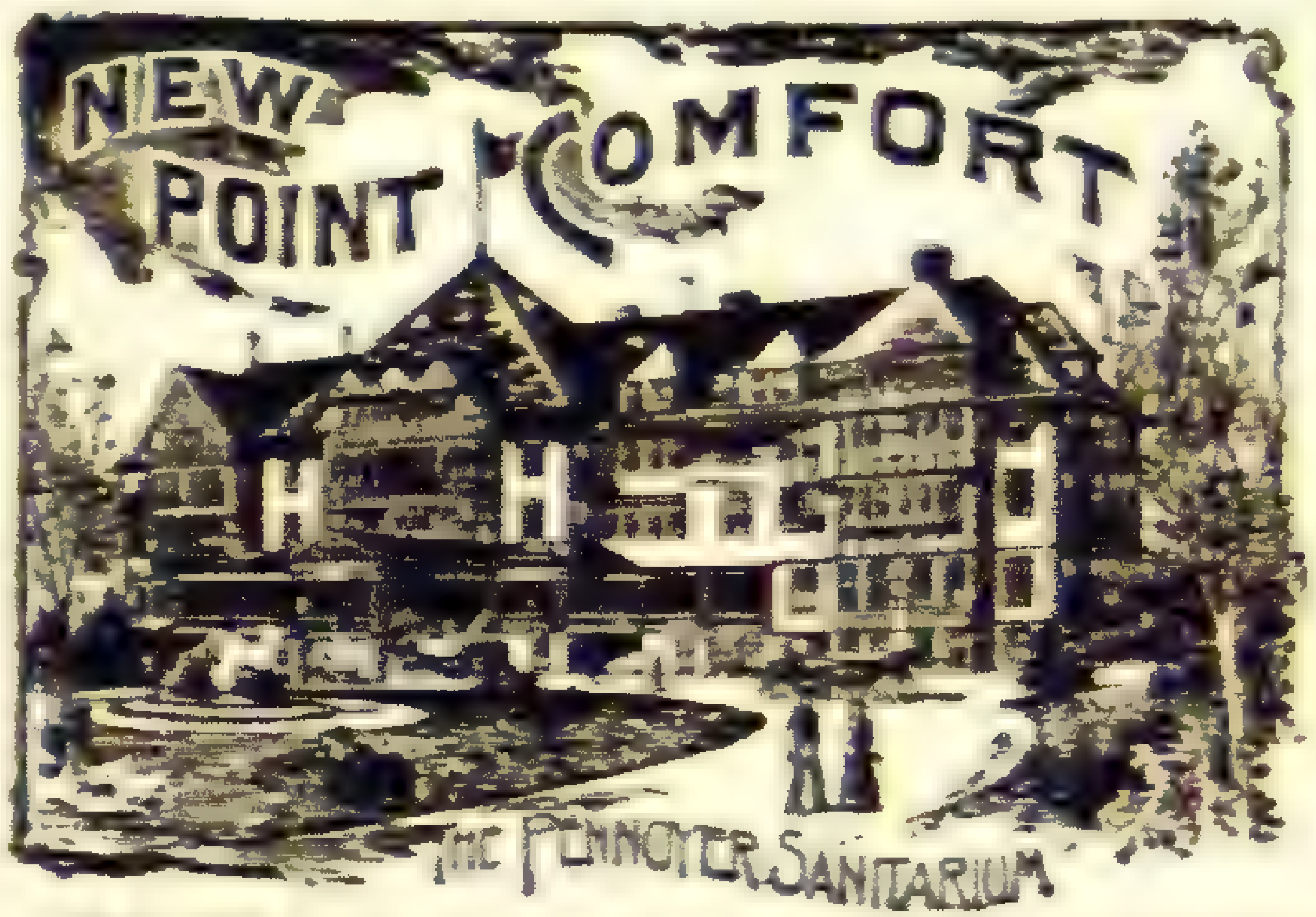

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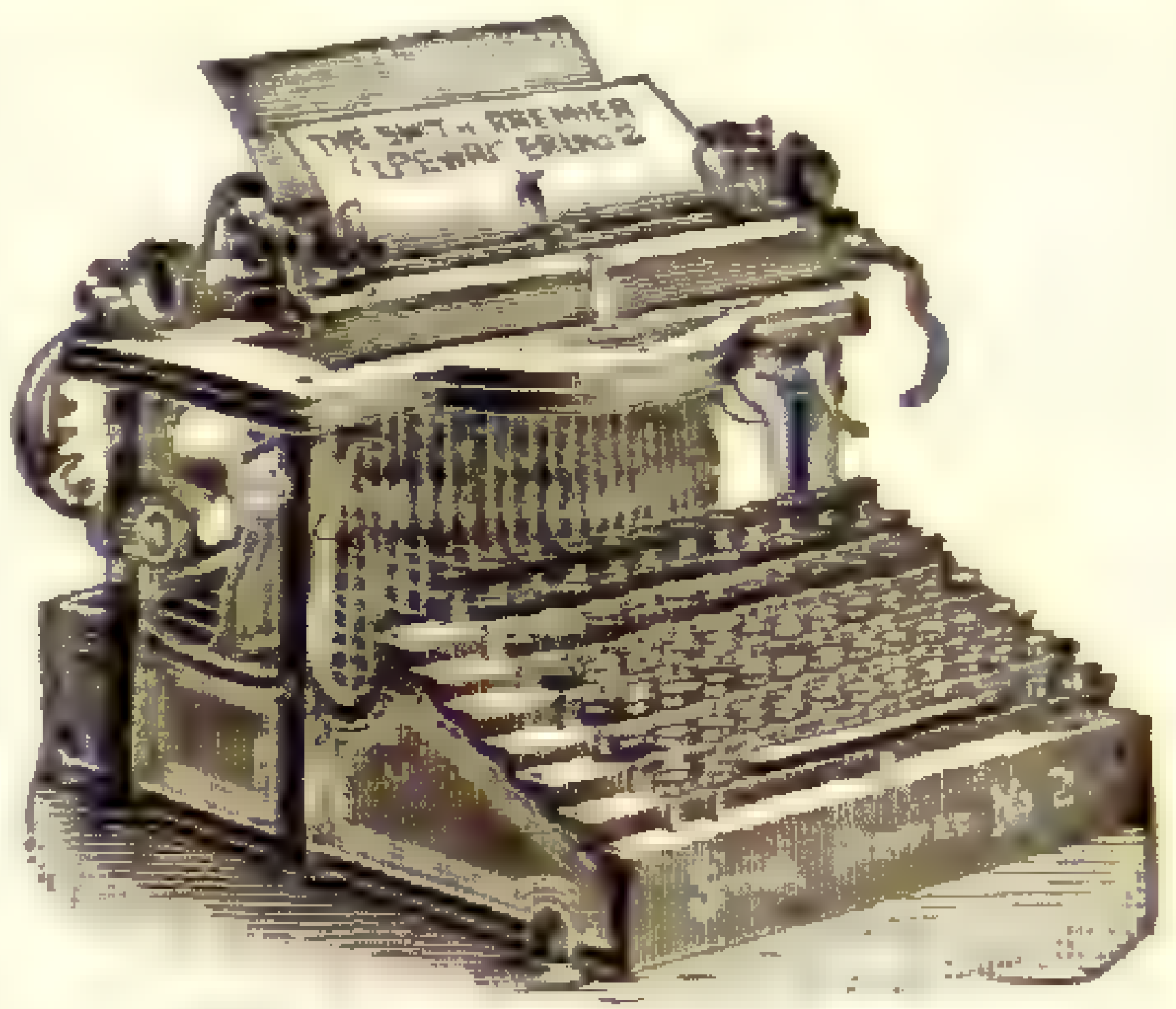

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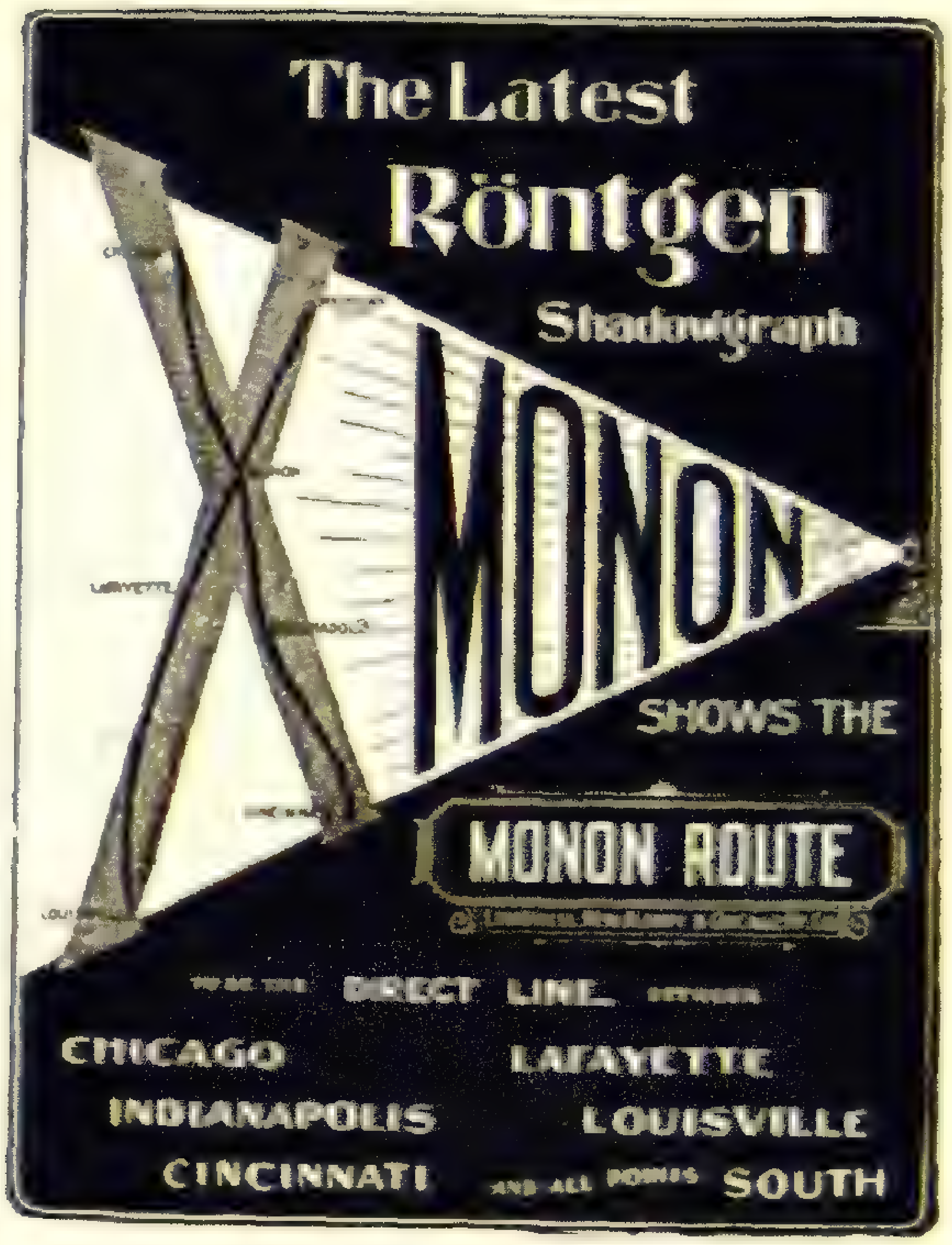
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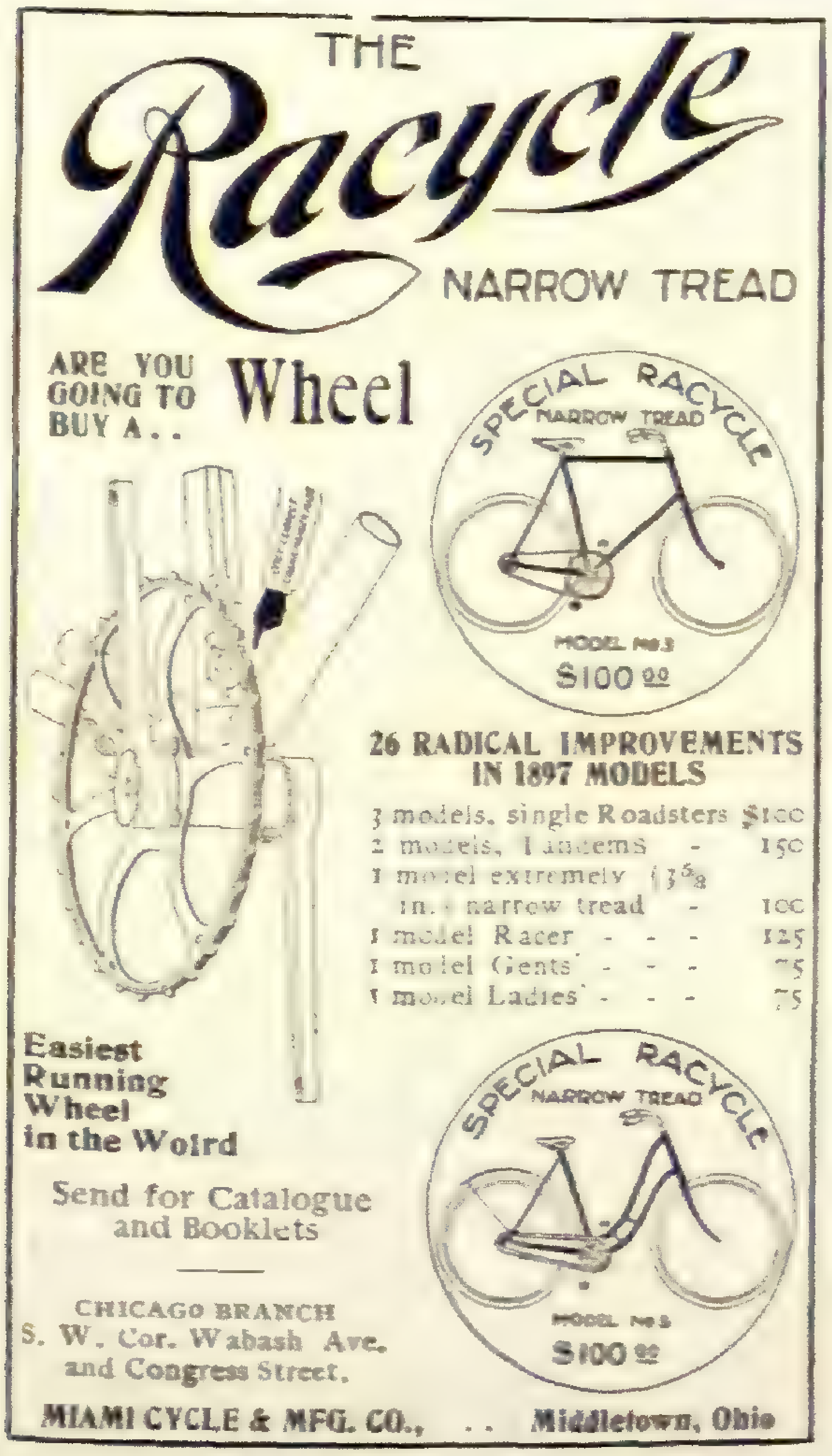
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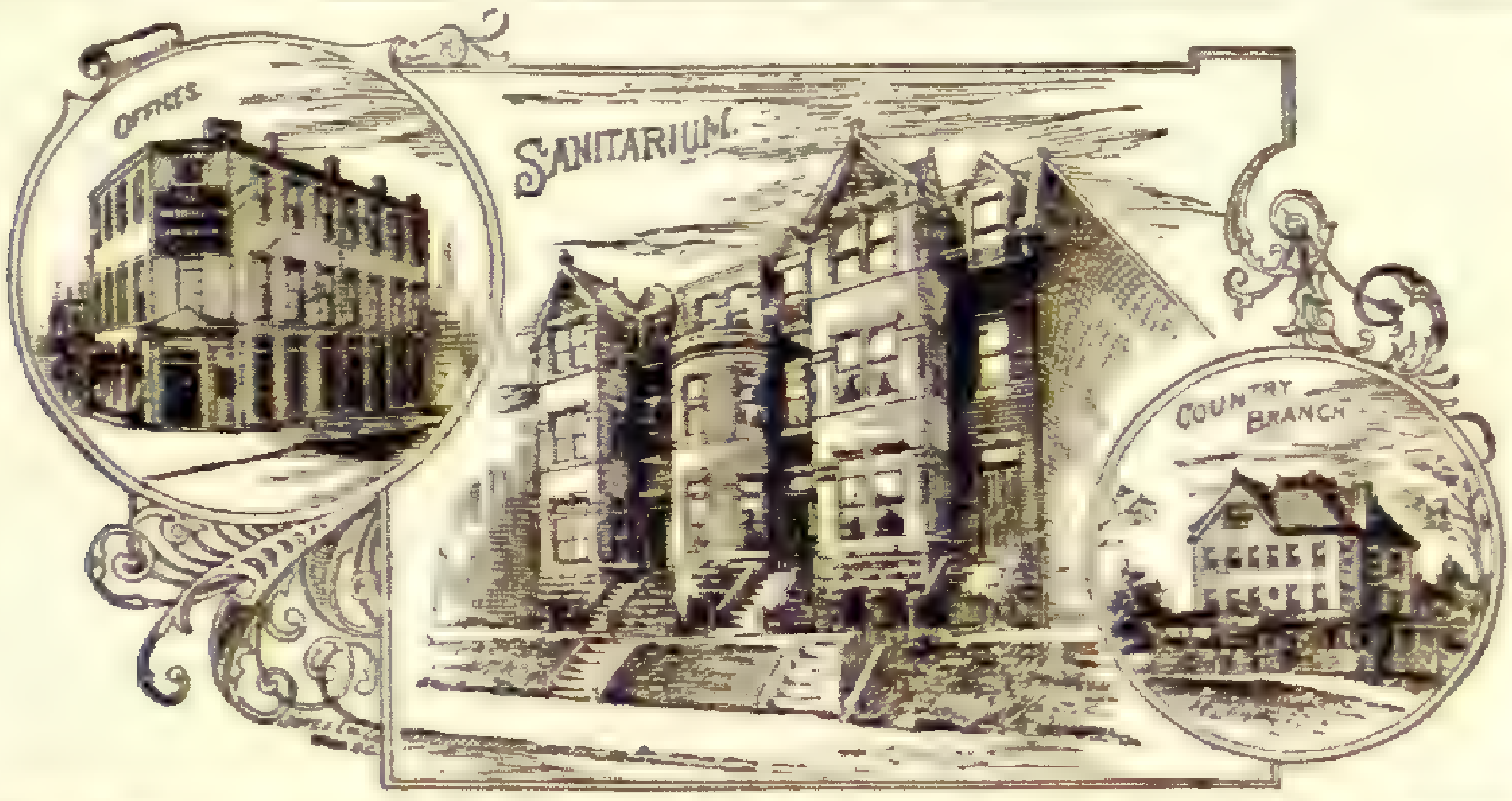

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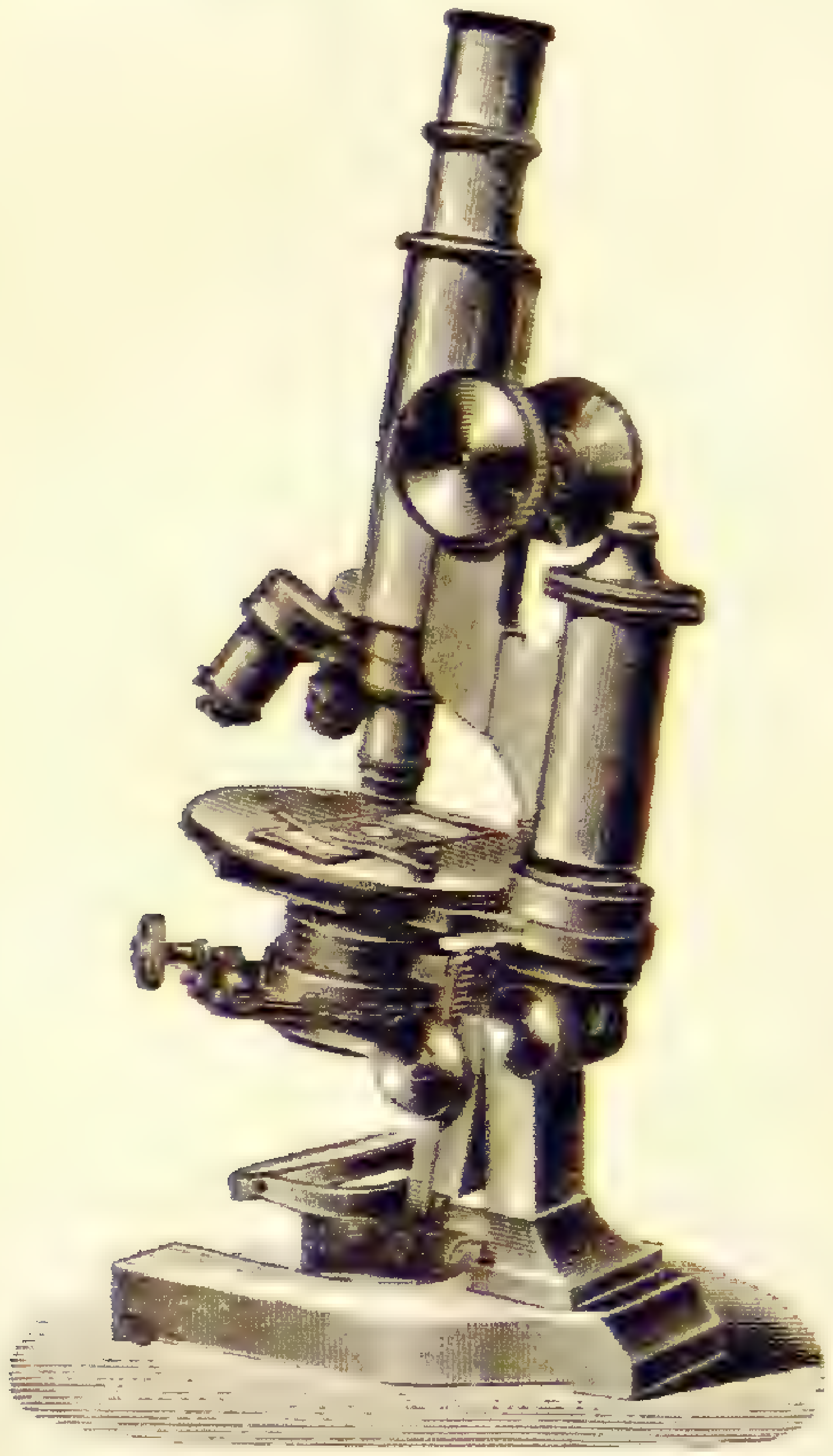

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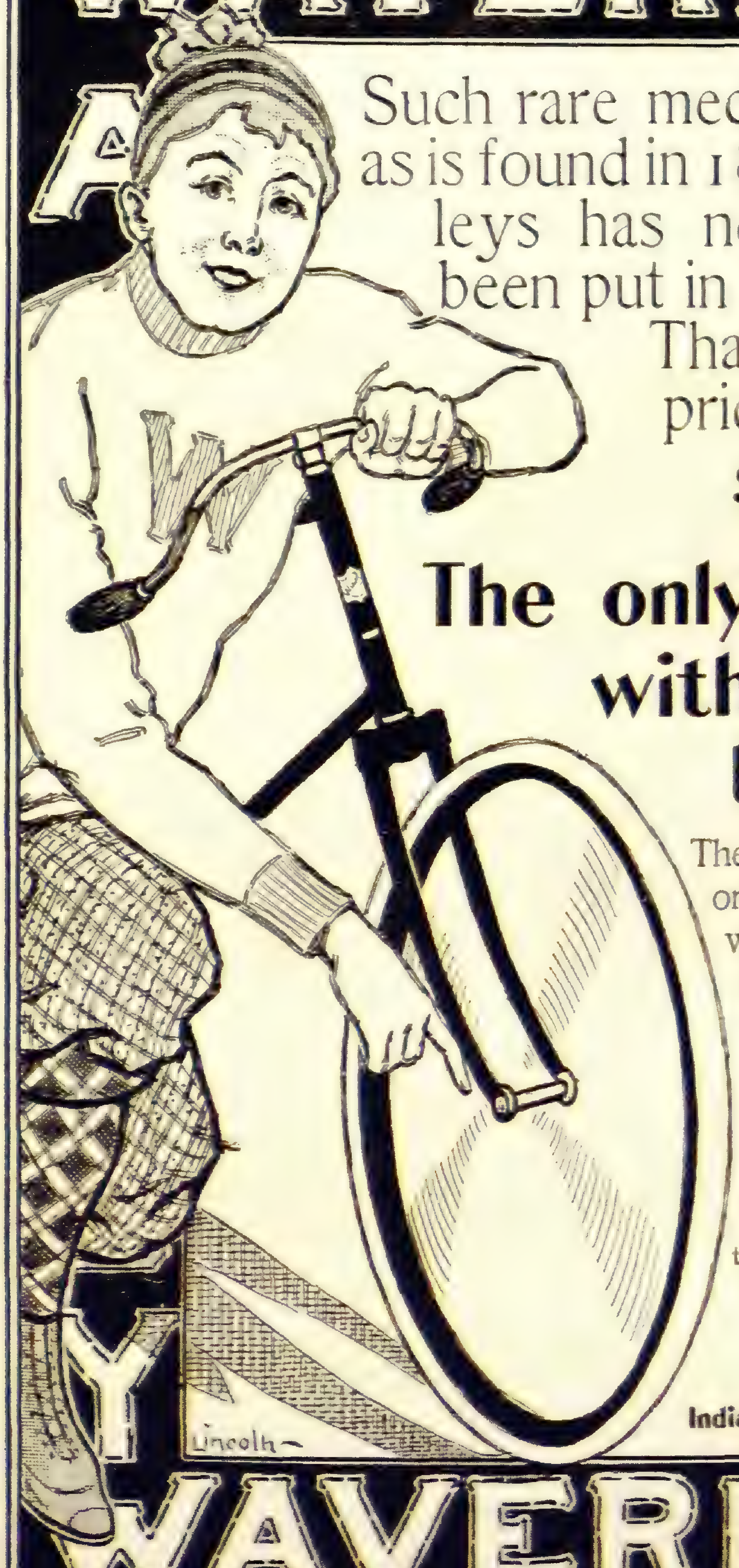

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While regular students are encouraged to make the Summer Quarter a part of their college course it is hoped and expected that many persons will enter The University for the Summer Quarter only, or for a single term of it. The programme of courses is therefore especially adapted to meet the needs of such persons. Many beginning courses are offered, and courses of study are so arranged that a student may devote his entire time for six weeks or three months to the mastery of a single subject under the direction of several instructors. In this way a student who desires to advance in any subject beyond the limits fixed by the resources of the preparatory school, either for the purpose of anticipating some portion of his college course or to fit himself for independent work in his chosen field of study or profession, can pursue his plan most profitably.

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THE
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BOTANICAL GAZETTE

APRIL 1897

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XVIII.

JOHN DONNELL SMITH.

CLEOME PILOSA Benth., var. **Costaricensis** Donnell Smith.—Folia majora longius petiolata 5–9-secta. Flores rosei. Pedicelli cum sepalis glandulosi gynophoro 3-plo longiores.

Cartago, Costa Rica, alt. 4250 ft., Nov. 1887, *Cooper*, no. 5709 Pl. Guat. etc., qu. ed. Donn. Sm.; Oct. 1894, *Biolley*, no. 8996 herb. nat. C. R.—Old fields near S. José, C. R., Nov. 1889, *Tonduz*, no. 1450 herb. nat. C. R.

Xylosma oligandrum Donnell Smith.—Inerme glabrum. Folia membrancea inter maxima penninervia oblongo-elliptica aut -obovata, apice acuminato, basi acuta, dentibus remotis exsertis. Flores fasciculati, pedicellis petiolos subaequantibus. Sepala 4 inter minima. Stamina circiter 10, glandulis 8 connatis. Ovarium ellipsoideum sepala bis superans, disco integro, stylo bifido, stigmatibus semilunatis.

A small tree (Biolley); branches glabrate, lenticellate. Leaves translucent, polished above, paler beneath, 5–6 × 2–2½ in.; nerves 6–8 to the side, long-ascending, prominent beneath; teeth glandular-mucronate; petioles very short. Pedicels 2–3 l. long, masculine flowers numerous, the feminine 5–8; bracts scarious, naked, cymbiform, minute. Sepals ovate, scarcely ½ l. long, pubescent within. Stamens glabrous, 1 l. long. Ovary smooth, placentae 2-ovulate. Berry by abortion 1–3-seeded.—By foliage similar to *X. intermedium* Griseb., but distinct by inflorescence and to be located with *X. Benthami* Griseb.

Borders of the river Surubres near San Matéo, Prov. Alajuela, Costa Rica, alt. 900 ft., July 1890, *Biolley*, no. 2652 herb. nat. C. R.

Stellaria Irazuensis Donnell Smith.— Caules humifusi glabri. Folia longe petiolata glabra ovata aut ovato-lanceolata, apice acuminato, basi leviter cordata, margine crispato-crenulato. Pedunculi terminales longissimi, ramis binis filiformibus recurvis, floribus tetrameris minimis in cymas bracteolatas confertis. Petala partita, segmentis lineari-spatulatis quam sepala sesquilongioribus. Ovarium globosum digynum tetraspermum.

Stems stramineous, branching, apparently 2–3 ft. long. Leaves ½–1 in. × 4–8 l., epunctate, bordered by an intramarginal nerve; petioles pubescent, 5–10 l. long. Peduncles 4–8 in. long, branches 3–4 in. long, branchlets ½–1 in. long; bracts foliaceous, subsessile; cymes glandulose-pubescent, several times dichotomous; axes 1–2 l. long; bracteoles glabrous, ½–1 l. long. Sepals 4, oblong-elliptical, obtuse, ¾ l. long, smooth and shining, 1-nerved. Petals 4, parted to near the base, a little longer than the 4 stamens. Ovary ½ l. high, equaling the uncinate styles, 4-valvate. Seeds reniform, red, punctulate. —Remarkable among American species by the 4-merous flowers, and by its other characters nearest to *S. micrantha* Spruce (no. 6023 *Spruce!* no. 47 *Fendler!*).

Oak-clearings, slope of Volcán Irazú, Prov. Cartago, alt. 6000 ft., July 1891, *Tonduz*, no. 4292 herb. nat. C. R.

Saurauia Costaricensis Donnell Smith.—Ramuli petioli costae paniculae calyces simul cano-pubescentes et ferrugineo-setosi. Folia obovato-oblonga aut -lanceolata acuminata ad basin acuta aut obtusa supra sparsim strigillosa subtus molliter et in costa nervisque densius pubescentia, margine inaequaliter mucronato. Paniculae longe pedunculatae amplae alternatim laxeque ramosae. Sepala intus subglabra petalis discretis glabris dimidio breviora. Styli ovario bis longiores. Bacca cano-lanuginosa.

A small tree. Bristles of branchlets paleaceous, puberulous, tipped with a hair, usually copious and spreading, occasionally more sparing short and appressed. Leaves 9–13 × 3¼–5 in., scarcely rough to the touch, sometimes glabrescent beneath, petioles 1–2 in. long. Panicles axillary, shorter than their peduncles, occasionally nearly as long as the leaves; bracteoles linear, 3–8 l. long; flowers hermaphrodite. Sepals nearly equal, 2 l. long; setose on the back, the 2 exterior ones everywhere, the 1 intermediate on one half, the 2 interior in a line; the 3 exterior ovate, setulose or at least pubescent on face near the apex; the 2 interior orbicular, glabrous on face and margin. Petals 4 l. long, 2 l. broad, each end obtuse. Stamens biserial, about 32, intermixed hairs white, filaments 1 l. long; anthers linear, 1 l. long, affixed near the middle, dehiscing by a slit. Ovary densely villous, styles 2 l. long. Berry globose, 4 l. in diam., enclosed by the accrescent calyx; seeds yellow, truncate-obpyramidal, ¼ l. long, deeply alveolate.—*S. scabrida* Hemsl., *S. strigillosa* Triana et Planch. and *S. Lehmannii* Hieron., with somewhat similar indument, differ from the above by scabrid leaves and glabrous ovary; *S. Veraguensis* Seem., related by its hirsute ovary, is distinct by tomentose sepals and petals.

Cartago, Costa Rica, alt. 4250 ft., Dec. 1887, *Cooper*, no. 5714 Pl. Guat. etc., qu. ed. Donn. Sm.—Rio Segundo, C. R., alt. 6000 ft., Jan. 1890, *Tonduz*, no. 1744 herb. nat. C. R.—San Márcos de Dota., C. R., alt. 3800 ft., Mch. 1893, *Tonduz*, no. 7685 herb. nat. C. R.—Alajuelita, Prov. S. José, C. R., alt. 3300 ft., Mch. 1894, *Donn. Sm.* no. 4745 Pl. Guat. etc., qu. ed. Donn. Sm.—Navarro, Prov. Cartago, C. R., alt. 3500 ft., *Donn. Sm.*, no. 4746 Pl. Guat., etc., qu. ed. Donn. Sm.—San José, C. R., alt. 3600 ft., Nov. 1894, *Pitt & Tond.*, no. 8959 herb. nat. C. R.

Saurauia Pittieri Donnell Smith.—Ramuli cum petiolis paniculisque ferruginei scabriusculi. Folia late oblongo-obovata, apice subobtuso, basi acuta, facie superiori tuberculis rubris scabrida, inferiori in costa nervis venis venulis canescente. Paniculae pedunculis longiores folia paene aequantes pyramidales, axibus alternis. Sepala parva petalis vix breviora utrinque canescentia tuberculis rubris extus punctata. Stamina pauca. Ovarium glabrum, stylis perbrevibus.

Arboreous. Younger parts rubescent, densely and minutely scabrid. Leaves 7½–10 × 3¾–5½ in., ending above in an obtuse and below in an acute angle; upper surface tubercular-punctate, otherwise glabrous; the lower besides the canescent reticulation sprinkled with a stellate pubesence; petioles ¾–1 in. long. Panicles axillary, 7–8 in. long, lowest branches 3–3½ in. long; bracteoles linear, 1–4 l. long; flowers hermaphrodite, 5 l. in diam. Sepals oval, 2 l. long; the exterior 2 tuberculose on the back, the intermediate 1 on a half of the back, the interior 2 in a dorsal line. Petals slightly connate, broadly oblong, glabrous. Stamens biserial, 20–24; filaments 1 l. long, at base sparingly barbate with white hairs; anthers somewhat shorter, oblong, affixed near the middle, dehiscing by a slit. Ovary ovate-globose, 5-sulçate, styles ¼ l. long. Berries not seen.—Easily recognized by the leaves not at all acuminate and the tuberculated calyxes.

Forests of La Palma, Pacific slope, Costa Rica, alt. 4800 ft., Sept. 1896, *Pittier*, no. 10163 herb. nat. C. R.

Pavonia oxyphyllaria Donnell Smith.—Rami petioli pedunculi simul pube stellata incana et pilis simplicibus patentibus

ferrugineis vestiti. Folia brevissime petiolata oblongo-elliptica acuminata ad basin angustam inaequalem 3-nerviam rotunda utrinque pilosa pellucida leviter lateque dentata. Flores pedunculati in axillis supremis solitarii albi. Bracteolae involucrantes 11–12 lineares teretes ciliatae calycem 4-plo superantes petala aequantes tubo stamineo bis longiores. Carpella bimucronata.

Fruticose, a foot and a half high. Leaves 3¼–4¼ × 1–1¾ in., the midrib and 6–8 lateral nerves ferruginous beneath, petioles 1–2 l. long and equaling the subulate stipules. Peduncle 6–7 l. long, recurved. Bracteoles of involucre distinct, half an inch long, beset everywhere with patent ferruginous hairs a line long. Calyx campanulate, 1½ l. high, velutinous outside, 5-nerved, veinless; teeth deltoid, ½ l. long, ciliate. Petals obliquely obovate, twice longer than broad, on each side pubescent, apex retuse. Staminal tube dentate, above the middle bearing subsessile anthers. Ovary depressed-globose, style exceeding by 1 line the staminal tube. Capsule not present in the specimens collected.—Apparently nearest to *P. Bahiensis* Guercke.

Borders of the river Verde, Hacienda de La Emilia, Llanos de S. Clara, Costa Rica, alt. 750 feet., May 1896, *Donn. Sm.*, no. 6449 Pl. Guat., etc., qu. ed. Donn. Sm.

Malvaviscus Palmanus Pittier et Donn. Sm.—Folia longe petiolata obovato-elliptica bis longiora quam latiora abrupte acuminata ad basin 3-nerviam acuta integra ad apicem versus denticulata supra pube adspersa subtus praeter nervos glabrescentia. Pedunculi ex axillis foliorum terminalium prodeuntes brevissimi. Bracteolae involucrantes 9 subulato-lineares calycem paene aequantes petalis 3-plo breviores.

Fruticose; branches, petioles and peduncles velvety; pubescence stellate. Leaves 6–7 in. long, pellucid-punctate, basal nerves stout and ascending to the upper third of the leaf; petioles 1½–2½ in. long; stipules triangular-linear, 5–6 l. long. Peduncles 3–4 at tips of stem and branches, half an inch long, bracteating leaves crowded and reduced in size. Bracteoles of involucre pubescent, 6 l. long, subterete. Calyx pubescent on outside, pellucid-punctate, 7 l. high, 10-nerved, triangular teeth 2 l. long. Petals scarlet, obovate-spatulate, 17 × 6–7 l., puberulous outside, apex retuse, basal auricle ferruginous-barbate. Staminal tube not yet exsert in the specimens seen, bearing at its apex deflexed filaments 1 l. long and twice longer than the elliptical anthers, subulate teeth 1 l. long. Ovary depressed-globose, lepidote; the style exceeding staminal tube by puberulous branches 1 l. long. Berry unknown.—Differing from all congeners by the leaves. The locality, La Palma, is situated on

the divide between the Atlantic and the Pacific slopes and is subject to a high rate of rainfall without distinction of seasons. It is remarkable for the number of new or rare plants that have been found in its neighborhood.

Forests of La Palma, Prov. S. José, Costa Rica, alt. 5100 ft., July 1895. *Tonduz*, no. 9712 herb. nat. C. R.

Quararibea platyphylla Pittier et Donn. Sm.—Folia pedalia ovalia altero tanto longiora quam latiora cuspidata ad basin rotunda inaequilatera omnino glabra, petiolis geniculatis. Flores singuli breviter pedunculati. Tubus stamineus calyce 4-plo petalis bis longior in septima parte superiori sparsim antheriferus, tubi lobis staminodia gerentibus.

Branchlets glabrous excepting the lepidote leaf-buds. Leaves coriaceous, basal nerves 3, the lateral ones 5–7 to the side and with naked axils; petioles stout, glabrous, verrucose, half an inch long, geniculate above the middle at a right angle. Flowers axillary. Calyx 3-bracteolate, twice longer than peduncle, on outside minutely lepidote but otherwise glabrous, sericeous inside, tubulous-obconic, in anthesis 6 × 3 l., breaking irregularly into 4–5 lobes. Petals cuneate-linear, 11 l. long, pubescent on outside. Staminal tube glabrous, 22–24 l. long; lobes oblong, 1 l., apiculate, punctate at apex with red staminodes; anthers 1-celled, about 28, glomerate above, subverticillate below, nearly adnate, occasionally geminate, reniform, ¾ l. long. Ovary semi-inferior, conical, style shortly exsert and pubescent at apex, superior lobe of stigma produced. Fruit not seen.—*Q. turbinata* Poir, similar in habit, differs chiefly by stamens and pistil little exceeding petals, anthers otherwise arranged.

Forests of the river Naranjo, Comarca de Puntarenas, Costa Rica, alt. 600 ft., Mch. 1893, *Tonduz*, no. 7579 herb. nat. C. R.

Buettneria macrocarpa Donnell Smith.—Frutex erectus inermis, ramulis teretibus petiolis inflorescentia minute stellato-pubescentibus. Folia longe petiolata glabrescentia integerrima acuminato-ovata aut ovato-lanceolata ad basin rotunda 5-nervia. Pedunculi axillares solitarii, cymis fructiferis petiolos aequantibus. Capsulae inter maximas generis spinis longis rigidis et aculeis brevibus dense armatae.

Leaves 4–6 × 2–3 in., midrib beneath pubescent and marked near the base with a linear gland, the interior basal nerves ascending nearly to apex of leaf, the lateral nerves 2–3 to the side, transverse veins conspicuous beneath, petioles 2–3 in. long. Peduncles in fruit 3–6 l. long, cymes 3–4 times dichotomous, pedicels 1½–3 l. long. Capsules depressed-globose, 8 × 10 l.; spines pubescent, pungent, 3–4 l. long. Nutlets crustaceous, dehiscing loculicidally to beyond the middle; seeds oval, 4 × 2½ l., glabrous, fuscous, cotyledons spirally convolute. Flowers not present in the specimens. — Related to *B. Carthagenensis* Jacq., which differs chiefly by the prickles and small capsule.

Borders of the river Ceibo near Buenos Ayres, Comarca de Puntarenas, Costa Rica, alt. 600 ft., Jan. 1892, *Tonduz*, no. 6689 herb. nat. C R.

✓ HELIOCARPUS POLYANDRUS Watson, var. **nodiflorus** Donnell Smith.— Arbor, foliis subtus velutinis, inflorescentiae ramis sarmentosis subflexuosis, nodis floribundis, inferioribus saepe foliatis, floribus dimidio majoribus.

Rio Pinula, Depart. Santa Rosa, Guat., alt. 4000 ft., Dec. 1892, *Heyde & Lux*, no. 4329 Pl. Guat., etc., qu. ed. Donn. Sm. sub. *H. Americanus* L., *forma floribus masculis pleiostemonis.*— Rio Torres, S. Francisco de Guadalupe, Prov. S. José, Costa Rica, alt. 3400 ft., Dec. 1893, *Tonduz*, no. 8453 herb. nat. C. R.

Erythroxylum Costaricense Donnell Smith. (§ ENGYANTHAE METRIOSEPALAE Peyritsch in Mart Fl. Bras.)— Folia digitalia oblongo- aut obovato-elliptica altero tanto longiora quam latiora acutissime acuminata in petiolum brevem cuneatim angustata pellucido-punctulata subtus glaucescentia, stipulis sicut ramentae striatis elongato-triangularibus petiolos superantibus. Flores pluri-glomerati breviter pedicellati. Sepala petalis dimidio breviora urceolum stamineum aequantia a filamentis 2–3-plo superata.

Branchlets terete, covered towards their tips with scales that are bifarious, imbricating, triangular-linear, half an inch long, aristulate. Leaves chartaceous, 3½–4 × 1½–2 in., terminating in a mucro, areoles and lines of prefoliation obsolete, petioles 2–3 l. long, stipules caducous. Glomerules 10–15-flowered; pedicels 1–1½ l. long, incrassate and pentagonal upwards; bracteoles scarious, striate, triangular, acute, subequaling pedicels. Sepals orbicular, ½ l. in diam., mucronate. Petals oblong, ligule a half shorter than the blade, lateral lobes conduplicate and crenulate, the commissural one most minute. Staminal tube in anthesis ½ l. high, slightly crenate, the longer filaments 1½ l. long. Ovary ellipsoid, ½ l. long, a little exceeding the 3 styles which are distinct from the base, stigmas capitate. Mature drupes not seen.— To be grouped with *E. amplum* Benth. and *E. laurinum* Triana et Planch.

Forests of Santo Domingo, Golfo Dulce, Costa Rica, little above sea level, Mch. 1896, *Tonduz*, no. 10092 herb. nat. C. R.

Oxalis vulcanicola Donnell Smith.—Trifoliastrum totum praeter flores ferrugineo-pilosum, radice fibrosa, caulibus decumbentibus ramosis, stipulis ad apicem liberis. Foliola obovata, lateralia paulo minora et ad basin inaequalia, apice deltoideo-emarginato. Pedunculi folia superantes multiflori, pedicellis gracilibus. Sepala glabra lineari-lanceolata petalis dimidio breviora staminibus majoribus triente pistillo dimidio longiora. Filamenta glabra. Capsula oblonga sepala aequans, loculis oligospermis.

Herbaceous, 1–2 ft. long, towards extremities sericeous. Stipules linear, adnate except the triangular apex. Petioles ¾–1½ in. long. Leaflets subsessile, pilose especially beneath, 7–11 × 5–7 l., the terminal one cuneate at base, the lateral rounded below on the outer side. Peduncles axillary, single, filiform, 2–4 in. long, cymes 6–12-flowered; pedicels subaggregated, 4–6 l. long; bracteoles linear, 1–2 l. long. Sepals 3–3½ l. long, the alternate ones narrower and linear. Petals yellow, streaked with violet, 6–7 l. long. Pistil oblong; styles very short, occasionally filiform. Capsule 3–3½ l. long; seeds 1–4 to the cell, oval, ½ l. long, rugose, red.—Nearly related to *O. pubescens* HBK., which differs by an erect habit, smaller flowers, broad sepals, barbate filaments.

Borders of a stream at Sitio Birris, Volcán Irazú, Costa Rica, alt. 8500 ft., Mch. 1888, *Pittier*, no. 164 herb. nat. C. R.—Valley of Los Arcángeles, Volcán Irazú, alt. 5700 ft., May 1888, *Pittier*, no. 70 herb. nat. C. R.—Southeastern flank of Volcán Poas, C. R., alt. 5700 ft., Jan. 1889, *Pittier*, no. 869 herb. nat. C. R.—Volcán Turrialba, C. R., alt. 7000 ft., *F. N.-Cox*, no. 4757 Pl. Guat., etc., qu. ed. Donn. Sm. sub *O. pilosissima* Turcz.

Impatiens Turrialbana Donnell Smith.—Glaberrima. Folia opposita longe petiolata oblongo-elliptica utrinque acuta supra medium remote serrata. Pedunculi solitarii filiformes biflori. Flores toti concolores purpurei. Sepala 3, lateralia orbiculari-ovata petalum anticum cucullatum aequantia, saccus aeque latus atque longus a petalis lateralibus paulo superatus, calcari brevi incurvo ad apicem inflato. Ovarium in unoquoque loculo bispermum.

A large herb; branches dichotomous, sulcate, leafy chiefly towards the end. Leaves 2½–3¼ in. × 10–14 l., apiculate with a mucro, attenuated into petioles 9–15 l. long, often entire, paler beneath. Peduncles 1–1¾ in. long, pedicels ¾–1¼ in. long. Flowers minutely setulose-punctate. Anterior sepal 0, the lateral 4 l. long, obliquely subcordate at base, apiculate, colored,

many-nerved; saccate sepal 9 l. long and broad, spur 4 l. long. Anterior petal broadly oblong; the lateral oblong-elliptical, emarginate at apex, oval lobes 2 l. long. Filaments 3 l. long, anthers 1 l. long and broad. Capsule not seen.—Related by inflorescence and floral structure to the two New World species, but distinct from both by opposite leaves and large purple flowers.

Crossing of the river Birris on the road ascending Volcán Turrialba, Prov. Cartago, Costa Rica, alt. 7200 ft., May 1889, *Pittier*, no. 885 herb. nat. C. R. —Volcán Turrialba, alt. 7000 ft., Mch. 1894, *F. Nutter-Cox*, no. 4758 Pl. Guat., etc., qu. ed. Donn. Sm. sub. *I. fulva* Nutt.

Esenbeckia litoralis Donnell Smith. (§ HYMENOPETALAE Engl. in Mart. Fl. Bras.)—Ramuli dichotomi, novelli sicut petioli paniculaeque pubescentes. Foliola 3 membranacea supra fere glabra subtus praesertim ad nervos pubescentia obovata, apice rotundo aut breviter obtuseque cuspidato, basi cuneata, margine obsolete crenato, intermedium quam petiolus subteres multoties longius. Paniculae terminales trinae foliis breviores, ramis alternis brevissimis. Sepala et petala sicut bracteolae in dorso ciliata Ovarii tubercula parce minuteque verrucosa.

Branchlets spotted with lenticels, leafy towards their summit, the tip canosericeous. Petioles 5–9 l. long, semiterete towards their base. Leaflets sessile, minutely pellucid-punctate; the terminal one about 6 times longer than the petiole, 2½–4½ × 1¾–2½ in.; the lateral ¼ to ⅓ smaller, base unequal. Panicles furnished each one at base with a linear bract 1 l. long, racemiform, 1½–2 in. long, branches 2–3 l. long; bracteoles ovate, 1 l. long; flowers 5-merous, subglomerate. Sepals imbricate, semiorbicular, ½ l. high. Petals imbricate, oblong, 1½ l. long, obtuse, sparingly and minutely pellucid-punctate. Stamens equaling the petals, filaments dilated below, anthers cordate and lobed to the middle. Disk ¼ l. high, ¾ l. broad, 10-crenate. Ovary immersed; tubercles 5, minute, furnished with 3–5 yellow gland-like warts; cells biovulate; style subulate, ½ l. long. Capsule not seen.—*E. Acapulcensis* Rose is the most nearly related species; it differs by glabrous and long-petiolate leaves, ample panicles void of hairs, naked and closely punctate petals, ovary densely covered by erect warts. *E. Berlandieri* Baillon, likewise related, is distinct by spotted petals and the 4-locular ovary.

Dry prairies along the coast of the Bay of Salinas, Comarca de Puntarenas, Costa Rica, July 1890, *Pittier*, no. 3317 herb. nat. C. R.

Cormonema ovalifolium Donnell Smith. (*Colubrina spinosa* Donn. Sm. in Bot. Gaz. **23**: 4. 1897.)—Folia glabra subtus reticulata ovalia altero tanto longiora quam latiora breviter obtuseque

acuminata ad basin rotunda et juxta petiolum biglandularia. Pedunculi ad basin bracteosi pluri-fasciculati. Drupa globosa magna, epicarpio intus confluenti-granuloso, seminibus orbicularibus compressis erubescentibus punctatis, cotyledonibus laete prasinis.

Spines not present in the single specimen. Leaves subdistichous, 3½–5½ × 1¾–2½ in., both surfaces green, only the lower one reticulated; glands large, disk-shaped; petioles corrugated, canaliculate, 7 l. long. Peduncles and small ovate bracts rusty puberulous. Drupe 4½ l. in diam., thrice exceeding the cupule of calyx, dehiscing septicidally from the base and loculicidally from the apex; epicarp reddish, rugulose outside, within closely occupied by large yellow granules; nutlets crustaceous with hyaline sides; seeds with a glaucous bloom, 3 l. long and broad, convex on back, flat and scarcely angulate on face. Flowers not seen. – The two Central American species recently published by Dr. J. N. Rose in Contr. U. S. Nat. Herb. 3:315, differ from the above as follows: *C. Nelsoni* by smaller subrhomboid leaves reticulated on both surfaces, glands remote from the petiole, epicarp sparingly granulated, pale obovoid seed, white cotyledons: *C. Mexicana* (more nearly related) by elongated leaves narrowing from the middle downwards, few and naked peduncles, reticulated epicarp, dark obovoid seed. The remaining species, *C. spinosum* Reissek from Brazil, as described and figured seems distinct by lanceolate-elliptical leaves with pubescent nerves, short petioles, obovoid seeds with an angular face.

Forests along the river Zhorquin, Talamanca, Costa Rica, Mch. 1894. *Tonduz*, no. 8507 herb. nat. C. R.

No. 4569 herb. nat. C. R., likewise cited for *Colubrina spinosa*, is to be referred to *Cormonema Nelsoni* Rose.

RUBUS GUYANENSIS Focke, var. **vulcanicolus** Donnell Smith.— Folia pleraque quinata. Pedunculi parce aculeati.

Leaflets with parallel and close transverse veins, midrib aculeate beneath. Petals roseate, orbicular, 3 l. in diam., a little longer than the ovate-lanceolate sepals. Drupelets small, numerous, glabrous; receptacle linear, 3 l. long, glabrous.

Rancho del Achiote, S. W. flank of Volcán Poas, Costa Rica, alt. 6800 ft., Jan. 1889, *Pittier*, no. 806, herb. nat. C. R.—Rancho Flores, forests of Volcán Barba, Costa Rica. alt. 6200 ft., Feb. 1890. *Tonduz*, no. 2120 herb. nat. C. R.

Escallonia Poasana Donnell Smith.—Glabrescens. Ramuli alati sicut pedunculi glandulis stipitatis obsiti. Folia basi semiamplexicauli decurrenteque subsessilia obovato-cuneata obtusa discoloria nervis et venis pellucidis supra impressa subtus fusco-reticulata, margine revoluto glanduli-crenulato. Flores terminales solitarii. Calycis depresso-hemispherici lobi inaequales oblongo-triangulares remoti, pars libera petalis oblongis vix dimidio brevior. Capsula paene libera a stylo superata.

Branchlets closely leafy. Leaves subcoriaceous, 10–12 × 4–6 l., under surface white and conspicuously reticulated, midrib beneath puberulous. Peduncles about 3 l. long. Tube of calyx about equaling the peduncle, at base turbinate and glandulose, suddenly dilated above and puberulous, 5 l. in diam.; lobes 1½–3 l. long, glandular-margined, sinuses 1 l. broad. Petals 5 l. long, 1½ l. broad; the spreading tip orbicular, scarcely broader than the claw, reticulated. Stamens 3½ l. long, anthers 1 l. long. Style bifid at apex, 3 l. long. Capsule bilocular, placentas 4.—*E. myrtilloides* L., the most closely related species, is distinguishable by its naked subangulate branchlets, twice to thrice smaller and simply venose leaves, and spathulate petals.

Borders of the upper lake of the Volcán Poas, Costa Rica, alt. 7700 ft., Aug. 1890, *Pittier*, no. 2971 herb. nat. C. R.

Psidium savannarum Donnell Smith. (§ALBO-TOMENTOSA Berg, in Mart Fl. Bras.)—Totum pallide ochraceo-tomentosum. Folia opposita et alterna sessilia obovata obtusa aut angulo lato acuta deorsum cuneata discoloria supra tomentosella subtus pannosa crebre nervia. Pedunculi solitarii uniflori. Alabastra parva obovata aperta supra ovarium haud constricta. Calycis lobi 5 triangulares. Petala inaequalia glabra. Ovarium 3-loculare.

Annotinous branches (the only ones present in the specimens) subterete. Leaves 18–25 × 10–12 l., membranaceous, elevated-pellucid-punctate above; costa flat above, prominent beneath; nerves prominent beneath, the lateral about 20 to the side and straight, the conjunctive distant from margin and slightly arching. Peduncles about 8 l. long, the lowest from axils of minute oblong-obovate leaves. Flower-buds 4 l. long. Calyx before anthesis dentate, afterwards slightly produced above ovary; lobes 1½ l. long, acute, canosericeous within like disk. The 3 larger petals 4 l. long, obovate, a little longer and twice broader than the others. Stamens 3 l. long, anthers shortly oblong. Ovary obconical, scarcely longer than calyx-lobes, shorter than the linear and persistent bracteoles; placentae bilamellate, distinct from axis; ovules about 8-serial. Berry not seen.—Related by some of its characteristics to *P. basanthus* Berg, which differs, however, by velutinous indument, leaves obsoletely nerved and all scattered, patelliform calyx with rounded teeth, and ciliate petals.

Savanna at Buenos Ayres, Comarca de Puntarenas, Costa Rica, alt. 800 ft., Febr. 1891, *Tonduz*, no. 4033 herb. nat. C. R.

Calyptranthes Tonduzii Donnell Smith.—Ramuli teretes et cymulae pubescentes. Folia oblongo-elliptica e medio utrinque acuminata, raro oblongo-obovata, glabra opaca crebre nervia supra lucida et pallescentia subtus obscura. Pedunculi axillares solitarii 3-flori foliis multo breviores, pedicellis brevissimis. Baccae maximae operculo conico saepe appendiculatae 1–18-spermae, seminibus nonnullis saepe imperfectis, testa ossea, cotyledonibus planis minimis.

Small tree with a spreading head (Tonduz), densely branched, fruiting profusely. Leaves twice or thrice exceeding internodes, 15–21×6–9 l., coriaceous, limbinerved, upper surface variegated with white and green, the lower impellucid-punctate, midrib pubescent above, nerves distinct on both sides, margin revolute; petioles very short, dark. Peduncles from nearly all nodes, 4–5 l. long; lateral pedicels deflexed, 1 l. long, the intermediate obsolete. Berries globose, yellow, glandular-punctate, 4–5 l. in diam., crowned with short tube of calyx; operculum persisting laterally, 1 l. high and broad, obtuse, glabrous; epicarp coriaceous; cells 1–3; seeds globose or variously compressed, occasionally superposed; radicle terete, strongly incurved; cotyledons oblong, ½ l. long, nearly free. No flowers present in the specimens. —Abnormal as to seed and approaching *Myrtus*; otherwise nearest to *C. rigida* Sw.

Banks of the river Virilla, Prov. S. José, Costa Rica, alt. 3400 ft., Dec. 1895, *Tonduz*, no. 9822 herb. nat. C. R.

Eugenia Guatemalensis Donnell Smith. (§ RACEMOSAE Berg in Mart. Fl. Bras.)—Folia discoloria supra glabra subtus incana lanceolato-elliptica utrinque acuminata. Pseudo-racemi axillares 1–2-ni, terminales 4-ni, foliis breviores pauciflori. Calycis usque ad discum partiti segmenta glanduli-tuberculosa, interiora concava exterioribus 3-plo majora petalis paulo minora. Ovarium obpyramidale biloculare multiovulatum.

Branches smooth, at tips cano-pubescent. Leaves 2¾–3½×1–1½ in., densely pubescent beneath, pellucid-punctate, limbinerved, lateral nerves of both surfaces distinct; petioles glabrous, 3 l. long. Racemes pubescent, at first shortly corymbose, rhachis at length elongate and 10–16 l. long, 5–9-flowered, pedicels opposite and 2–3 l. long, terminal flower subsessile in the fork, bracts minutely subulate. Flowers rubescent. Sepals rubri-punctate, strigillose-pubescent on both sides, the larger orbicular and 1¼–1½ l. long, the smaller ovate. Petals orbicular, 1¾ l. long, glabrous, pellucid-punctate. Stamens 2 l. long, anthers globose. Ovary flavo-sericeous, 1¾ l. high, bracteoles minutely subulate, disk glabrous, ovules about 8 to the cell, style 2½–3 l. long. Mature berries not seen.

Forests of Santa Rosa, Depart. S. Rosa, Guatemala, alt. 5000 ft., July 1887, *von Türckheim*, no. 1318 Pl. Guat., etc., qu. ed. Donn. Sm.

Jussieua geminiflora Donnell Smith. (§ EUJUSSIAEA Micheli)—Fruticosa glabrescens. Folia subsessilia elongato-lanceolata ad basin acuminata. Flores singuli aut bini brevissime pedicellati tetrameri parvi. Calycis tubus in medio lineari-bibracteolatus lobos aequans petala orbiculari-ovata paulo superans. Discus leviter elevatus. Stylus crassus brevissimus. Capsula obovoideo-globosa.

Shrub 6–8 ft. high, branching freely, branchlets subterete, the younger ones pubescent. Leaves membranaceous, puberulous on midrib and nerves, otherwise smooth and shining on both surfaces, 3–4×¾–1 in., slenderly and acutely elongated, decurrent to the very short petiole. Pedicels most often geminate, puberulous, in anthesis ½ l. long, in fruit 2 l. long. Bracteoles 2 l. long, ¼ l. broad, free from the small subulate stipels. Calyx sparsely pilose; the tube tetragonal-obconic, 2 l. long; lobes triangular-lanceolate, 1 l. broad. Petals 1½–1¾×1¼ l. Disk pubescent, ½ l. high. Stamens a little exceeded by stigmas; anthers subsessile, torulose, ¾ l. long. Style ¼ l. long, ecostate. Capsule 5×3½ l., scarcely angulate; seeds oblong, ⅓ l. long, estriate, punctulate.—Nearly related to *J. latifolia* Benth., which differs chiefly by ovate leaves, solitary flowers, lanceolate bracteoles, petals broader than long, and very elevated disk.

Confluence of the rivers Puerto Viejo and Sarapiqui, Costa Rica, Jan. 1893, *Biolley*, no. 7379 herb. nat. C. R.—Swampy thickets, Atirro, Prov. Cartago, Costa Rica, alt. 1800 ft., Apr. 1896, *Donn. Sm.*, no. 6502 Pl. Guat., etc., qu. ed. Donn. Sm.

Passiflora Pittieri Mast. (§ ASTROPHEA)—Arbuscula ut videtur fere ecirrata; ramis angulatis sulcatis brevissime puberulis; petiolis 15 mill. superne sulcatis ad basin laminae glandulosis; stipulis petiolis dimidio brevioribus lineari-subulatis; foliis 9–10×4 cent. subcoriaceis glabris oblongis abrupte acuminatis; pedunculis axillaribus petiolis duplo longioribus supra medium articulatis; bracteis dissitis setaceis parvis; flore diamet. 6 cent., tubo glabro 12 mill. infundibuliformi; sepalis 40 mill. long. crassiusculis oblongo-obtusis exappendiculatis; petalis sepalis conformibus

iisque parum brevioribus tenuoribusque; corona fauciali pluriseriali filamentosa, filis extimis petaloideis dolabriformibus, petalis dimidio brevioribus, sequentibus approximatis brevioribus; corona media e medio tubi assurgente cylindrato-tubulata; gynandrophoro tenue angulat o glabro; filamentis angustis; ovario oblongo-truncato striato, fulvo-tomentoso, stylis cylindratis tomentosis ab angulis ovarii profisciscentibus eoque duplo longioribus crassiusculis; stigmatibus oblique capitatis.

An interesting species allied to some British Guianan forms and in some measure intermediate between section *Astrophea* and other sections.

Thickets of Santo Domingo, Golfo Dulce, Costa Rica, Mch. 1896, *Pittier*, no. 9894 herb. nat. C. R.

Passiflora pediculata Mast. (§ DECALOBA.)—Ramis gracilibus glabris, petiolis elongatis ad 6–7 cent. long. gracilibus eglandulosis vel versus basin glandulis 2 sessilibus onustis; stipulis caducis lineari-subulatis; laminis 5 × 9 cent. papyraceis glabris rotundatis basi cordatis 3-nerviis, antice fere ad medium trilobatis, lobis oblongis obtusiusculis late divergentibus, mediano longiore; pedunculis gracilibus petiolis parum brevioribus; bracteis approximatis caducis lineari-subulatis parvis; flore circa 3 cent. diam.; tubo glabro pateriformi; sepalis oblongis obtusis; petalis conformibus minoribus; corona fauciali e filis petaloideis uniseriatis transversim violaceo-fasciatis petalis parum brevioribus constante; corona media membranacea integra tubulata inflexa; corona infra mediana annulari crassa; ovario ellipsoideo glabro, stylis lineari-clavatis.—Florem unicum tantum examinavi.

Thicket on banks of the river Torres near San Francisco de Guadalupe, Prov. S. José, Costa Rica, alt. 3400 ft., Feb. 1893, *Tonduz*, no. 7250 herb. nat. C. R.

Carica dolichaula Donnell Smith.—Inermis. Folia digitatim 3–5-foliolata, foliolis longiuscule petiolulatis. Corollae tubus lobos multoties excedens. Filamenta breviter monadelphia, antheris magnis dimorphis, alternis prope medium affixis leviter bilobis, omnium connectivo supra articulationem bialato. Pistillum rudimentarium longissimum.

Tree 20 ft. high, branching, glabrous in all parts. Leaflets 3- or 4- or 5-nate, thin-membranaceous, glaucous beneath, oblong- or obovate-elliptical, abruptly acuminate, base chiefly acute, midrib and the few patent nerves conspicuous beneath; terminal leaflet about as long as the general petiole, 5–6×2–2¼ in; exterior leaflets decreasing in size, unequal at base; petiolules 4–8 l. long. Racemes (the male only seen) disposed in a terminal panicle leafy below, peduncles 1–1½ in. long. Calyx 1 l. high, triangular lobes equaling tube. Corolla white; tube 2–3 in. long, 1 l in diam.; lobes oblong-elliptical, 5–7 l. long, dextrorsely (as seen from the inside) convolute. Superior anthers 2 l. long, adnate to somewhat shorter filaments; the inferior opposite to the lobes, sessile, 3½ l. long; connective slightly produced, appendaged on the back with a dilated rubro-punctate membrane a little shorter than the connective and free at the tip. Style from the rudimentary ovary linear, half an inch long. Female flowers and berries not seen.—Readily distinguished by the length of the flowers and structure of the stamens from all species of the doubtfully distinct genera *Carica* and *Jaracatia*. Popularly called *Papaya del Monte*.

Forests bordering the river Zhorquin, Talamanca, Costa Rica, March 1894, *Tonduz*, no. 8509 herb. nat. C. R.—Suerre, Llanos de Santa Clara, Costa Rica, alt. 900 ft., April 1896, ***Donn. Sm.***, no. 6526 Pl. Guat., etc., qu. ed. Donn. Sm.

Siphocampylus discolor Donnell Smith.—Frutex pube pallide ochracea totus fere furfuraceus. Folia supra pube sparsim punctata subtus ochracea in costa nervis venis furfuracea obovato-oblonga acuminata deorsum attenuata glandulis passim denticulata. Pedunculi folia aequantes, bracteis filiformibus. Calycis tubus ovalis segmentis linearibus parum brevior. Corollae albae usque ad medium fidae tubus segmentis calycinis vix longior superne inflatus, laciniis inaequalibus falcatis secundis. Antherae majores in vertice nudae, omnes linea media albo-pubescentes ceterum glabrae.

Branchlets subalate by decurrent petioles. Leaves 7–9×2–2½ in., petioles 7–10 l. long. Peduncles from upper axils, glabrescent, bracts 5–10 l. long. Flowers 2½–2¾ in. long. Tube of calyx in anthesis 5–6 l. long; segments 7–10 l. long, glandular-denticulate. Tube of corolla more or less furfuraceous, an inch long, segments linear-lanceolate, the 2 superior ones 12–13 l. long and twice exceeding the others. Staminal column glabrescent; anthers exsert, 7 l. long. Capsule globose-oval, ¾ in. long, pubescent-punctate; ribs 10, furfuraceous.—Nearest to *S. foetidus* G. Don.

Forests of Rancho Flores, Volcán Barba, Costa Rica, alt. 6700 ft., February 1890, *Tonduz*, no. 2149 herb. nat. C. R.—Forests of Volcán Irazú, C. R., alt. 6200 ft., July 1891, *Tonduz*, no. 4241 herb. nat. C. R.

Siphocampylus roseus Donnell Smith.—Herbaceus glabrescens. Folia longiuscule petiolata ovata acuminata ad basin imam cuneata, denticulis inaequalibus glandula fusca apiculatis. Pedunculi ad basin bracteati folia subaequantes. Calycis tubus turbinatus segmenta linearia serrulata aequans. Corollae roseae segmentis calycinis 6-plo longioris tubus incurvus claviformis, lobi breves oblongi acuminati erecti, laterales falcati, anticus altius solutus. Genitalia inclusa, antheris majoribus sub apice barbatis.

Stem decumbent, repent at base; branches assurgent, 2–3 ft. long, the younger parts cano-pubescent. Leaves alternate, 3¼–5¼×1½–3¼ in., glabrous except midrib and nerves of lower surface, petioles ¾–2 in. long. Peduncles axillary, 2–3¼ in. long, puberulous; bracts linear, 2 l. long. Ribs of calyx-tube canescent; segments 3–4 l. long. Corolla puberulous, 1¾–2 in. long; lobes albescent within, the anterior one 5 l. long, the others 4 l. long. Anthers nearly glabrous below the apex. Capsule globose-oval, 8–10 l. long, apex shortly conical.—Related to *S. glandulosus* Hook.

Confluence of the rivers Sarapiquí and Puerto Viejo, Costa Rica, near sea-level, April 1892, *Biolley*, no. 6922 herb. nat. C. R.—Banks of river Pacuare, Comarca de Limón, C. R., alt. 600 ft., April 1896, *Donn. Sm.*, no. 6628 Pl. Guat , etc., qu. ed. Donn. Sm.

LIPPIA SUBSTRIGOSA Turcz., var. **oxyphyllaria** Donnell Smith.—Caules et ramuli teretes. Folia elliptica -aut lanceolato-elliptica e medio utrinque acuminata. Pedunculi 1–2-ni, capitulorum rhachi usque ad 8 l. longa, bracteolis ovato-lanceolatis, extimis longius acuminatis 8–9 l. longis.

Borders of forest at Térraba, Comarca de Puntarenas, Costa Rica, alt. 800 ft., February 1891, *Pittier*, no. 3951 herb. nat. C. R.—Thickets along the river Ceibo near Buenos Ayres, C. R., alt. 1000 ft., February 1892, *Tonduz*, no. 6667 herb. nat. C. R.

The typical form of this species seems to be represented by the following specimens from Guatemala, which differ from the above by tetragonal branches, ovate leaves abruptly contracted into petiole, peduncles several in the axes, orbicular-ovate bracteoles: nos. 2006, 4387, 4389 Pl. Guat., etc., qu. ed. Donn. Sm.; no. 3610 *Nelson*.

Salvia Pansamalensis Donnell Smith. (§ CALOSPHACE, *Longiflorae* Benth)—Caules herbacei glabri. Folia supra parce pilosa

subtus glabra lanceolato-elliptica longe caudato-acuminata deorsum angustata mucronibus exsertis dentata. Racemi foliis reductis fulti in paniculam saepe dispositi, verticillastris bifloris, bracteolis purpureis ellipticis cuspidatis calycem superantibus. Calycis purpurei labia brevissima, posticum subintegrum subtruncatum, antici dentes triangulares. Corollae purpureae tubus ventricosus calyce et labiis subaequalibus 3-plo longior. Genitalia inclusa.

Stems several from a fibrillose root, simple, 1–2½ ft. high. Leaves 4–5½×1–1¾ in., the prolonged tip 5–8 l. long, base and apex not dentate, lower surface pale and minutely reticulated, petioles 3–4 l. long. Racemes 2–4 in. long, closely flowered; pedicels flavo-pubescent, 1 l. long; bracteoles 6 l. long, ciliate. Calyx tubulose-campanulate, 4–5 l. long, nerves ciliate. Corolla pubescent above, smooth within; superior lip oblong and entire, the inferior much broader and oval. Style glabrous. Gland of disk twice longer than nutlets.

Pansamalá forest, Depart. Alta Verapaz, Guatemala, alt. 4000 ft., June 1886, *von Türckheim*, no. 933 Pl. Guat., etc., qu. ed. Donn. Sm. Specimens under this number have already been distributed as *Salvia sp.* to various herbaria.

Costus podocephalus Donnell Smith.—Vaginae elongatae striatae pubescentes in lobos 2 rotundatos breviter productae, foliis glabris subtilissime nervatis elongato-lanceolatis caudato-acuminatis ad basin sessilem acutis. Pedunculus subexsertus bracteatus. Strobilus ovoideus, bracteolis dense imbricatis erectis striatis oblongis, inferioribus obtusis mucronatis, superioribus acuminatis. Flores inclusi. Calyx partitus corolla tubulosa genitalibusque parum brevior.

Leaves 11–13×2½–3 in., minutely rubro-punctate beneath, slender cusp 6 l. long; sheaths sprinkled with a tufted paleaceous pubescence, rubro-punctate; lobes 2–3 l. long, externally tomentulose, internally colored and reticulated. Bracts of peduncle 2, an inch distant, 2–3½ × ½ in., slenderly cuspidate, tomentulose toward apex. Strobile 2½–3¼ in. long, stramineous; bracteoles 15–18×5–6 l., pubescent, the mucro tipped with a deciduous awn. Perianth 5–6 l. long, tomentulose toward apex; calyx-segments lanceolate, conduplicate, the third one obsolete, margins hyaline; corolla striate, the triangular lobes 1½ l. long. Stigma hemispherical, ciliate. Developed staminodes and the capsules not present in the specimens.

Guápiles, Llanos de Santa Clara, Costa Rica, alt. 850 ft., Apr. 1894, *Donn. Sm.*, no. 4972 Pl. Guat. etc., qu. ed. Donn. Sm.—Forests of Shirores, Talamanca, Costa Rica, alt. 300 ft., Febr. 1895, *Tonduz*, no. 9238 herb. nat. C. R.

Myrosma Guapilesense Donnell Smith. (§ SARANTHE)—Folia glabra oblongo-ovalia subito acuminata ad basin imam cuneata, radicalia longissime petiolata, caulinum 1 terminale ceteris nec superatum. Paniculae ad apiceum caulis 2 longe pedunculatae corymbosae, spicis binis dense bracteosis, flore superiori pedicellum aequante, inferiori in medio pedicelli communis subsessili. Sepala petalis latiora vix breviora. Ovarium profunde 9-sulcatum.

Rhizome repent, 3–4 in. long, articulations vaginate, roots fibrillose. Radical petioles distichous, 1 ½ ft. long, nearly glabrous; articles geniculate, 10–11 l. long, puberulous on face. Leaves 10–12 × 4–4 ½ in., the cauline somewhat smaller, its petiole 7 in. long. Flowering stem 13–15 in. long; peduncles pubescent at base, 2 ½–3 ¼ in. long, somewhat exceeding the linear bracts; spikes 1–2 ½ in. long, flexuous; bracteoles distichous, 7–9 l. long, 3–4 times exceeding internodes, at first pubescent, enclosing a pair of flowers. Sepals oblong-elliptical, 4–5 l. long, scarious, glabrous, multinerved, nigro-mucronulate. Petals oblong, acute, nigro-apiculate. External staminodes multinerved, emarginate; appendage of stamen shorter than anther. Ovary shortly cylindrical, 2 ½ × 2 l., slightly pilose at apex, crenately-angular, cell reticulated; ovule 1 ½ l. long, rubescent; aril minute, bifid. Fruit not seen.

Guápiles, Llanos de Santa Clara, Costa Rica, alt. 850 ft., Apr. 1894, *Donn. Sm.*, no 4970 Pl. Guat., etc., qu. ed. Donn. Sm.

GYMNOGRAMME CERATOLEPIS (*Asplenium Ceratolepis* Christ in Bull. Soc. Bot. Belg. **35**: 203), var. **Atirrensis** Donnell Smith. —Pinnae integrae aut leviter crenatae, discretarum venae cunctae adscendentes liberae marginem attingentes, connatarum vena infima cum ea pinnae contiguae juxta rhachin arcuatim conjuncta.

In the typical specimens (no. 1170 herb. nat. C. R.!) the pinnae are lobed to their middle with a conjunctive vein near the midrib. The sori, present in all stages of development, exhibit, as Dr. Christ has also remarked, no traces of an indusium.

Swampy thickets at Atirro, Prov. Cartago, Costa Rica, alt. 1800 ft., Apr. 1896, *Donn. Sm.*, no. 6882 Pl. Guat., etc., qu. ed. Donn. Sm.

BALTIMORE, MD.

CONTRIBUTION TO THE LIFE HISTORY OF SAGITTARIA VARIABILIS.[1]

JOHN H. SCHAFFNER.

(WITH PLATES XX–XXVI)

THE following work upon Sagittaria was begun in October 1896, and is a continuation of my former work on *Alisma Plantago*,[2] to which paper frequent reference will be made for comparison. So far as the writer knows, no special work has been done upon the gametophyte generation of Sagittaria, or upon its embryology. The material used was killed in a solution of chrom-acetic acid and preserved in 70 per cent. alcohol, and the usual methods of imbedding in paraffin and staining on the slide were employed. The stain used for the greater part of the work was a double stain of anilin-safranin and gentian-violet.

The investigation was carried on under the direction of Dr. John M. Coulter, to whom I here express my thanks for assistance and criticism.

The flowers of *Sagittaria variabilis* are all monosporangiate, but frequently there are abortive carpels at the center of the staminate flower. Some varieties are monœcious and others diœcious. The carpels, which become achenes, are spirally arranged upon a very globose receptacle, as are also the stamens. The ovules are apotropous. In the earlier stages they are anatropous, but later they become strongly campylotropous, so that the mature embryo is bent double and becomes horseshoe shaped. Both the staminate and carpellate flowers have nectaries which are active during the blooming period. The nectaries are situated around the base of the flower, between the carpels and the petals. They appear to be simply modified carpels. The glandular secreting cells are epidermal and are situated around the lower part (*fig. 1*), usually extending to the adjoining carpels, which often remain sterile and develop no embryo. The secreting cells begin to enlarge about the time the embryo sac is formed, and after fertilization is accomplished they cease their activity and become more or less shrunken and disorganized. During their active period the cytoplasm of these cells has the characteristic glandular appearance, and the nuclei are drawn out into irregular shapes, often having thick projections like pseudopodia (*fig. 45*).

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[1] Contributions from the Hull Botanical Laboratory. IV.

[2] The embryo sac of Alisma Plantago. BOT. GAZ. **21**: 123–132. 1896.

DEVELOPMENT OF THE MALE GAMETOPHYTE.

As no suitable material was available the early development of the anther was not studied. The pollen mother cells were found dividing abundantly. In these numerous figures in the mother star stage showed large and well defined centrospheres at the poles (*fig. 2*), and although the exact number of chromosomes was not determined the reduction was ascertained to take place at this division. This fact should be kept in mind in connection with any theoretical explanation of the phenomenon of reduction, as it will be seen that the two daughter nuclei arising from the reduction nucleus do not belong to the first cells of the sexual generation, but to the mother cells of the microspores with which the sexual generation properly begins. By the time the nucleus of the pollen mother cells is in the close mother skein stage, two centrospheres appear at each pole of the spindle. By successive divisions the two microspore mother cells form the cells of the tetrad. These cells, which usually lie in one plane (*fig. 4*), soon separate, and with little or no increase in size develop into the microspores. The microspores possess a very thick wall, from whose outer surface are developed prickly projections (*fig. 5*).

The microspore soon begins to enlarge and the first division of its nucleus takes place, giving rise to the generative and tube nuclei. The two nuclei are at first quite similar, but they soon differentiate, the tube nucleus becoming larger, and the generative nucleus appearing to develop more chromatin, and thus always taking a deeper stain. Although no special staining was employed, centrospheres were frequently seen beside the resting generative nucleus. The pollen grain now rapidly grows to its mature size, and the generative nucleus immediately divides into the two sperm nuclei. These are small and spherical at first, and always stain so deeply that little or no structure can be seen in them (*fig. 7*). This division of the generative nucleus takes place long before the anther has reached its mature size and is ready to dehisce. After the pollen is shed the sperm nuclei no longer appear spherical, but are bean shaped or spindle shaped, and the tube nucleus shows a difference in its reaction, since it now stains almost as deeply as the sperm nuclei themselves, and shows little or none of its internal structure (*figs. 8, 9*). Whether the sperm nuclei organize definite cells I could not determine. The spindle shaped appearance may have been produced by the accumulation of a small amount of cytoplasm at the two ends, but if this was really the case my staining produced no differentiation between nucleus and cytoplasm. The division of the generative nucleus before pollination seems to be quite common in monocotyledons, and it is probable that this condition will be found to be the rule rather than the exception in this group.

DEVELOPMENT OF THE FEMALE GAMETOPHYTE.

Because of a lack of suitable material the development of the macrospore could not be worked out. The earliest stage found was a four-celled embryo sac (*fig. 10*). The two nuclei at the micropylar end arise by longitudinal division, while the two lower ones are produced by a transverse division. After the next divisions, which produce the typical eight-celled embryo sac, the nuclei begin to travel to their proper positions, while at the same time large vacuoles appear in their rear. The nuclei of the synergids, the nucleus of the oosphere, and the lower polar nucleus are about the same size, while the upper polar nucleus is by far the largest nucleus in the sac (*figs. 11, 12*). The three antipodal nuclei are considerably smaller than the others, and even at this early stage, before the conjugation of the polar nuclei and the act of fertilization, they are often cut off by well defined cell walls (*fig. 11*).

In approaching each other the upper larger polar nucleus travels much farther than the lower one, so that the place of contact is usually in the lower part of the embryo sac (*figs. 14, 19, 25*), and the fusion takes place here without any apparent shifting of the nuclei, the fusion being usually complete before the entrance of the pollen tube into the sac (*fig. 19*). Frequently two centrosomes with a common hyaline area around them can be seen on one or both sides of the conjugating nuclei (*fig. 13*), indicating a possible union of the two pairs of centrospheres which are brought together when the two nuclei approach each other. Later the appearance is as though the two centrosomes had fused (*figs. 15, 16*). Although these observations were not very extensive, they agree with what I observed in the conjugating polar nuclei of *Alisma Plantago.* There is usually one large nucleolus in each polar nucleus, and during the fusion of the polar nuclei their nucleoli also seemed to fuse. When the nuclear fusion is nearly complete, two or three nucleoli appear close together (*figs. 15, 16*), and a little later the nucleoli are seen to lie in contact (*figs. 17, 18*). When nuclear fusion is completed, the definitive nucleus nearly always shows but one large nucleolus (*figs. 19, 29*), so there can be but little doubt from the stages observed that the nucleoli come together and fuse directly as definite bodies, without breaking up or being dissolved.

PHENOMENA OF FERTILIZATION.

Just before the entrance of the pollen tube into the micropyle, the two synergids lie side by side, with the oosphere suspended below and lying somewhat to one side (*figs. 14, 19, 20*). In the lower part of each synergid there is a large vacuole. At this stage the nucleus of the oosphere is usually quite symmetrical, being spherical or ellipsoidal in shape.

It will be remembered that the pollen grain has the two sperm cells fully differentiated before pollination. As the tube passes through the micropyle it is considerably constricted, but when it reaches the apex of the embryo sac it increases appreciably in diameter. The tube takes exactly the same course as in Alisma, passing down on one side near the wall of the sac, and encountering the nucleus of one of the synergids, which disappears at this time and is never seen again (*figs. 21, 25, 26, 29*). The other synergid, with its nucleus, persists for a long time, and can still be seen above the vesicular suspensor cell of rather large embryos (*figs. 65, 69*). The pollen tube after entering the embryo sac stains very dark, and it is often difficult to distinguish the two sperm nuclei as they are traveling down the tube. In lightly stained material, however, they can be seen very readily. As the lower one approaches the tip of the tube it is preceded by two centrospheres, which can be seen always in well stained sections because of their position and the light colored cytoplasm with which they are usually surrounded (*figs. 22, 23, 24, 26, 28*). When the sperm nucleus breaks out of the tube it makes a decided perforation, the appearance being as though the tip had been softened and the nucleus had broken forcibly out of it. In some cases the edges of the perforation are rather smooth, while in other cases they are somewhat ragged (*figs. 29, 30, 31, 32*). A stream of cytoplasm escapes from the tube after the lower sperm nucleus (*fig. 30*), but the upper sperm nucleus never leaves the tube (*fig. 32*), which is also the case in Alisma. After the rupture of the pollen tube, the cytoplasm between the sexual cells usually contains numerous granules, which may have escaped from the tube, or they may be fragments of the disintegrated tip of the tube (*figs. 25, 27*). This often makes it difficult to identify the centrospheres at this stage, it being very easy to lose sight of them entirely although they may be present in the section.

In the meantime changes have been taking place in the oosphere. Its nucleus is no longer symmetrical in outline, but, just as in Alisma, it is drawn out into a considerable bulge on the side toward the sperm nucleus (*figs. 21, 24, 29, 30*). This bulging of the female nucleus toward the male nucleus has also been observed in *Pinus Banksiana* and *P. Laricio.*[3] In the case of the large female nucleus of Pinus, however, the bulging appears only as a papilla-like protuberance, while in Alisma and Sagittaria the whole side of the nucleus appears to be drawn out. What the physiological significance of this bulging is cannot be stated, but it seems to be one of the characteristic phenomena of fertilization in the higher plants.

Although the method of staining employed did not bring out the centrospheres of the oosphere nucleus as readily as those of the sperm nucleus, they were sometimes seen, and when they appeared they were found lying just beyond the bulge of the oosphere nucleus toward the sperm nucleus (*fig. 21*). Thus, during the approach of the two sexual nuclei each one is preceded by its two centrospheres. Just before the contact of the sexual nuclei, two pairs of centrospheres appear on opposite sides of the approaching nuclei (*fig. 30*), and when the nuclei are in contact a little later, the two pairs appear to be fusing (*fig. 31*). These appearances are the same as those I observed during the fusion of the polar nuclei of Alisma, and seem to point strongly to a pairing and subsequent fusion of the four centrospheres which are thus brought together. Although these appearances very properly can receive such an explanation, it must be borne in mind that other movements and other explanations are possible. Thus, the two centrospheres which appear on the upper side in *figs. 30* and *31* may be interpreted as belonging to the female nucleus, while the lower pair may have come from the male. This would do away with the so-called "quadrille movement." I think, however, that Guignard's explanation of a conjugation in pairs is the more reasonable one, from the fact that during fusion of cells not only the nuclei themselves fuse, but apparently also the cytoplasm, chromatophores, and pyrenoids, indicating that during fusion all protoplasmic bodies of the same nature in the cells are involved in the act. The evidence which led me to infer a pairing of centrospheres during the fusion of the polar nuclei in Alisma was the fact that just before the contact of the nuclei the centrospheres appeared a little farther apart as though they were separating. The interpretation in such cases, however, necessarily must be merely an inference, and could not be decided absolutely except by observing the phenomena in the living condition, which at present seems entirely out of the question in the case of the higher plants, unless a system of differential centrosphere stains can be developed. The whole subject must depend upon the question as to whether centrospheres are permanent bodies in the cell and deserve to rank with other cell organs. Although our knowledge in regard to these bodies is still too fragmentary to make any positive assertions, the permanent organ theory certainly seems to be receiving constantly new confirmation. . Recently Lauterborn[4] has studied these bodies in certain diatoms, in which he was able to see centrosomes very readily, even in the living condition. This is a direct confirmation of the work done by Bütschli,[5] who made the same observation in 1891. As far as my own observation goes, I can come to no other conclusion. These bodies appear so often that they can not be overlooked by a careful observer. They appear beside the resting nucleus, in the higher plants always two in number, and later at the poles of the spindle in the mother star stage. A little later, having divided into two, two centrospheres appear at each pole of the spindle, sometimes so prominent that they are as much in evidence as the nucleus itself (*fig. 34*). There is no reason why at times, especially during abnormal conditions, the centrospheres should not fragment or break up into a number of pieces, just as is the case with the nucleus, but any objections raised as to the individuality of centrospheres because of such action can have no more weight than a similar argument against the individuality of the nucleus because it frequently fragments or dissolves. It makes little difference what the function of the centrosphere is finally discovered to be; the presence of the body must be explained. That its function may have been misinterpreted is no argument against its existence. The centrosome may be a mere insertion point for spindle threads and cytoplasmic radiations, as Heidenhain seems to suppose; it may be the special organ of division and a truly directive sphere; it may be even more, and have some function in transmitting hereditary characteristics; but whatever its function may be, the point to be decided first is its existence. If this is established, questions as to its origin, purpose, and permanency naturally follow.

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[3] Bot. Gaz. 23: 40, 41. 1897.

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[4] Untersuchungen über Bau, Kernteilung und Bewegung der Diatomeen. Aus dem Zoologischen Institut der Universität Heidelberg. Leipzig, 1896.

[5] Über die sogenannten Centralkörper der Zelle und ihre Bedeutung. Verhandl. des Naturhist.-Med. Vereins zu Heidelberg. N. F. 4: 535-538. 1891.

The appearance of two centrospheres at the poles of the spindle (*figs. 3, 34*), it seems to me, cannot be explained by a crossing of cytoplasmic filaments; by an attraction from the periphery to a common center; or by the rather lately broached idea of a sort of whirlpool in the cytoplasm. So far as the writer is able to judge, no one has attempted to offer a satisfactory explanation of these double centers at the poles on the theory of their temporary nature, since he called attention to them in 1894.[6] At this stage these bodies can be identified readily, and there is no danger of mistaking other granules of the cytoplasm for centrospheres.

In this connection I wish to refer to Humphrey's[7] implied criticism of my former work on centrospheres. He intimates that, having largely used Hermann's method of staining centrospheres, I may have mistaken various proteid granules in the cytoplasm for true centrospheres. My only reply to this is that I was fully aware of the fact that many small bodies in plant cells often greatly interfere with the identification of centrosomes, and, therefore, a large number of stains and methods of killing were used in order to eliminate any faulty observations which might be possible in using only a single method of preparation. It must be recognized that methods of fixing and staining do not give the same results when used by different observers.

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[6] The nature and distribution of attraction spheres and centrosomes in vegetable cells. BOT. GAZ. **19**: 449. 1894.

[7] On some constituents of the cell. Ann. Bot. **9**: 574. 1895.

Even plants of the same species and different parts of the same plant, when treated in exactly the same way, will react quite differently, and one must practically invent a new process for every form studied if reliable results are to be obtained.

THE ANTIPODAL REGION.

As already stated, the three antipodals are surrounded at an early stage by very definite cell walls, although in certain cases the formation of walls may be delayed for some time. When the embryo is two-celled, the embryo sac is still quite narrow, and tapers very gradually into the antipodal region (*figs. 36, 37, 39*); but after this it widens out greatly, leaving the antipodal region, which in the meantime has developed very thick cell walls, as a sort of vermiform appendix to the lower part of the sac (*figs. 40, 41, 42, 43*). The antipodal region, with its three nuclei, persists even in the fully formed ovule, where it always produces a very striking appearance because of the constancy with which it preserves its original shape and dimensions. In these late stages, however, the antipodal nuclei stain a very deep color, so that they appear almost entirely homogeneous (*figs. 40, 41, 42, 43, 44, 73*). It is probable that this persistence of the antipodal region may be much more common than is generally supposed, and that it may often have been overlooked and reported as disappearing when it was actually present and persisting even in the mature ovule.

DEVELOPMENT OF THE ENDOSPERM.

In the development of its endosperm Sagittaria presents some very interesting peculiarities. The first division of the definitive nucleus takes place about the same time as the first division of the oospore; and what is most remarkable, at this division a cell plate is formed between the daughter nuclei, which cuts the embryo sac transversely into two compartments (*figs. 36, 37, 38, 39*). This transverse wall will be called the partition wall. Because of the difference in the behavior of these two nuclei, to avoid ambiguity, the one on the micropylar side of the partition wall will be called the upper endosperm nucleus, and the one on the antipodal side of the partition wall the lower endosperm nucleus.

The upper endosperm nucleus immediately begins to travel upward on the convex side of the embryo sac wall, and immediately begins a rather rapid free nuclear division (*figs. 37, 38, 39*). At the same time the ovule takes on its campylotropous shape, the sac almost doubling on itself, and the elongation practically all taking place above the partition wall (*figs. 38, 41, 73*). In the early stages the free endosperm nuclei are about equally distributed from the embryo down to the partition wall. After the embryo has reached nearly the mature condition the numerous free endosperm cells, which in the meantime have accumulated above the partition wall, begin an active process of free cell wall formation, forming quite a large cap, which extends over the tip of the cotyledon and crowds down upon the partition wall, forcing its outer margin downward (*figs. 44, 73*).

In the meantime no such process has been going on in the compartment below the partition wall. The lower endosperm nucleus does not divide for a long time, but increases considerably in size (*fig. 40*). Its first division usually occurs at the time when the embryo is about seven or eight celled, and it is nearly always divided when the embryo is from nine to eleven celled. Sometimes one of the nuclei may divide again, thus producing three nuclei (*fig. 43*), or it may be that the three nuclei were produced by direct division. No more than three nuclei were observed in any stage, although it is possible that sometimes there may be more. These nuclei increase enormously in size, being as large or even larger than the giant nucleus of the vesicular suspensor cell. They are nearly always closely crowded together (*fig. 43*), and at the time of the free cell wall formation of the upper endosperm they appear to break up and take on the deep stain which is characteristic of the antipodal nuclei (*fig. 44*). When the ovule has reached maturity, all that can be seen of these nuclei is an irregular mass of red stained material situated just above the antipodal region in a sort of pocket cut off by the partition wall (*fig. 73*). Just what the function of these lower endosperm cells may be the writer is not prepared to state. In the earlier stages the whole compartment has a glandular appearance, much like the vesicular cell of the suspensor. It seems possible, therefore, that it may play an important part in the transfer of food material from the funicular region, beyond the antipodals, to the cotyledon, and especially in facilitating the formation of the cap of endosperm which covers the tip of the cotyledon.

DEVELOPMENT OF THE EMBRYO.

After fertilization the large spherical nucleus of the oospore lies in about the same position as that occupied by the oosphere nucleus before fusion (*fig. 32*). The oospore now begins to push downward into the sac and is surrounded by a definite cell wall, and usually one or more large vacuoles appear above it (*figs. 33, 35*). The formation of vacuoles in the rear of moving nuclei seems to be of quite general occurrence, especially in the embryo sac. The nuclei seem to be carried along by the streaming of the cytoplasm, which as it advances develops a vacuole behind it.

The first division of the oospore is transverse (*figs. 36, 38, 39*). After this the lower cell elongates and divides again by a transverse wall, making the first three cells of the pro-embryo, which are thus produced in acropetal succession (*fig. 46*). The upper cell never divides, and forms the vesicular suspensor cell, which immediately begins to increase enormously in size. The lowest cell gives rise to the terminal cotyledon, and its first division, which may occur immediately (*fig. 47*) or may be delayed for a considerable length of time, is always longitudinal. The middle cell gives rise to the apex of the stem, the hypocotyl, the root tip, and all the suspensor cells except the vesicular cell, its divisions occurring in basipetal succession. The general course of events, therefore, is the same as that given by Hanstein and Famintzin for *Alisma Plantago*, except in certain details and variations which will be mentioned later, and does not agree with my own observations on the early development of the embryo of Alisma, where I found four cells produced in acropetal succession before the longitudinal division of the terminal cell. I am inclined now to regard this as only an exceptional variation. However, such a variation may also occur in Sagittaria, since the succession of divisions of individual cells in an embryo does not seem to be so invariable as was once supposed. Sometimes as many as five cells in a single chain were observed without any indication of a longitudinal division in the terminal cell (*fig. 52*). In such a case, of course, it is impossible to tell just how the various cells originated unless one is fortunate enough to find cases in which the nuclei are in the spindle stage.

I do not consider it proper in this case to call the terminal cell, which gives rise to the cotyledon, the embryo cell, but shall call it what it really is, the cotyledon cell. Nor does it seem reasonable to include the middle cell in the suspensor. It will be seen that the development of the embryo proceeds gradually, and to call one cell a suspensor cell which at the next division becomes a cell of the embryo, is drawing an arbitrary line where none exists. The cell at the upper or micropylar end can be called properly a suspensor cell, since it never contributes to any part of the embryo proper, but is subsequently destroyed. The cells which finally become a permanent part of the suspensor between the vesicular cell and the embryo are variable in number and are a late development. There is always, except in rare cases, at least one cell between the developing embryo and the vesicular suspensor cell, which by basipetal divisions contributes to the development of the root-tip, and finally develops a filamentous suspensor, and this cell may be called a temporary suspensor cell. But it seems to me that in cases like Sagittaria the only reasonable terminology is to regard as embryo cells all those which go to make up the embryo, and to restrict the term suspensor to that part which never contributes to the formation of the embryo.

Taking the usual course of events, the third division is in the middle cell, which divides transversely, making a chain of four cells (*figs. 46, 48*). The succeeding division is in the terminal cell, which divides longitudinally, giving rise to the first two cells of the cotyledon (*figs. 49, 50*). The cell *b* (*fig. 49*) gives rise to the stem tip, while the cell *d* (*fig. 49*) divides transversely, forming the six-celled pro-embryo with five tiers of cells (*figs. 51, 53*). The next division is in the cell *b*, which divides longitudinally (*figs. 54, 55*), and gives rise to the seven-celled pro-embryo (*fig. 56*). During this time the remaining synergid is a very active cell, and appears to assist the vesicular cell in its function (*figs. 46, 48, 54, 55*). There now occur several divisions in rapid succession, but not always in the same order. Usually the two terminal cells divide longitudinally; the cell *d* (*fig. 59*) also divides longitudinally; while in the cell above this transverse division occurs, giving rise to an eleven-celled pro-embryo with six tiers of cells (*figs. 57, 58, 59, 60, 61*). Each one of the four terminal cells now divides transversely (*fig. 62*), so that the young cotyledon becomes an octant. That the process is not always so typical will be seen from *fig. 63*, where one of the four cells has divided longitudinally, and another one is dividing transversely, while there are only five tiers of cells.

After the formation of the octant of the cotyledon, the next thing which usually occurs is the cutting off of the dermatogen by periclinal divisions in these eight cells, and the same process usually goes on in the tier above at the same time (*fig. 64*). The cell in tier *e* (*fig. 64*) now divides longitudinally, while the cell *f* (*fig. 64*) still remains single (*fig. 65*). In one case, however, I observed that this cell *f* (*fig. 66*) also had divided longitudinally. This is a very interesting variation, since it would change the entire course of the development of the root tip and suspensor. It is another illustration showing that no hard and fast lines can be drawn for the development of an embryo. The early stages of the embryo are quite apt to show variations which from their fundamental character must change the whole future course of development. The predestination of cells for a certain fixed course of development agrees neither with our present ideas of development nor with observed facts.

Taking up again the general course of embryonic development, we have next the differentiation of the apical area of the stem, which begins in a hypodermal cell of tier *b* (*fig. 67*). Another transverse division of the cell *f* (*fig. 64*) occurs, while at the same time the cotyledon also undergoes further development (*figs. 67, 68, 69*). It will be noticed, therefore, that the cotyledon is the earliest region to be developed, and that the apex of the stem follows. The development of the apical region of the stem is continued by transverse divisions of the neighboring dermatogen cells of tier *b* (*fig. 69*), and later the remaining cells of this tier also divide by transverse walls (*fig. 70*). At this stage the vesicular suspensor cell appears to be in its most active condition, but from this time on it begins to disorganize. At this time, and for some time later, the entire embryo is meristematic, and division may take place in any part. In the meantime, after considerable growth, the cell *g* (*fig. 70*) divides by a transverse wall, forming another tier *h*, the lower cell dividing again longitudinally into four cells (*fig. 71*). Whether tiers *e* and *f* (*fig. 71*) arise from tier *e* (*fig. 70*) I could not determine, although from the difference in size of the cells of the two tiers it seems probable that they do not. The embryo now begins to elongate, showing a deep depression on the side where the stem apex is situated, and there is a farther development of cells between the embryo and the vesicular cell (*fig. 72*). At this stage the embryo sac is of almost mature proportions, and the embryo as it grows downward bends around the curve of the sac, very likely because of the mechanical resistance offered by the walls within which it is confined, and thus acquires its hooked form (*fig. 73*.)

DIFFERENTIATION OF DERMATOGEN, PERIBLEM, AND PLEROME.

The development of dermatogen begins at the apex of the cotyledon, and as the embryo develops the dermatogen extends farther and farther toward the point where the apex of the root will finally be developed. Just how many tiers of cells go to make up the hypocotyl and root tip it seems impossible to determine; in some cases, no doubt, more tiers than in others, since the growth upward seems to have no special definite limit. A variable number of suspensor cells are developed. Sometimes as many as six cells are left for the suspensor, besides the vesicular cell, after the definite limits of the embryo are determined by the completion of the dermatogen around the root tip (*fig. 75*). At this stage the suspensor is usually broken. The dermatogen is thus fully developed before the plerome strand is differentiated enough to be recognized. A hypodermal cell of the root tip is differentiated, and by transverse division forms the initial cell of the plerome strand (*figs. 76, 77, 78, 79*), while at the same time the central primary meristematic tissue is developed into the plerome by longitudinal cell divisions. The plerome and periblem in most cases can be traced downward to this initial cell. The calyptrogen is developed by transverse divisions of a small number of dermatogen cells of the root tip, which by further divisions form a very small root cap for the young embryo (*figs. 77, 78, 79*).

The arrangement of tissues in the mature embryo is well shown by cross sections. At the apex a single central cell appears (*fig. 80*), and a little farther up the differentiation of the plerome strand and periblem are well marked out (*fig. 81*). A section about through the center of the hypocotyl shows a well-marked dermatogen, and inside of this three layers of large periblem cells with large intercellular spaces. In the center the plerome is composed of a bundle of twelve or more long narrow cells, surrounded by a circle of nine or more larger cells forming a sheath (*fig. 82*). Finally, a longitudinal section through the stem apex shows a very deep cleft with the first leaflet already somewhat developed (*fig. 83*).

SUMMARY.

1. Broadly speaking, the development of the pollen grain, embryo sac, and embryo of *Sagittaria variabilis* is the same as in

Alisma Plantago, although there are some striking and important differences.

2. The generative nucleus divides into the two sperm nuclei long before the dehiscence of the anther, making a three-nucleated pollen grain.

3. In the eight-celled embryo sac the upper polar nucleus is by far the largest, and the point of contact and of fusion of the two polar nuclei is in the lower part of the sac, the fusion usually being completed before fertilization.

4. During the fusion of the polar nuclei the centrospheres and nucleoli also appear to fuse.

5. The three antipodal cells are usually surrounded by cell walls before fertilization, and the antipodal region, having developed unusually thick walls, retains its original size and contents even when the embryo is fully formed, projecting somewhat like a vermiform appendix beyond the limits of the enlarged sac.

6. After conjugation, the first division of the definitive nucleus takes place at about the time of the division of the oospore, and at this first division a cell plate is formed making a partition wall which completely separates the embryo sac into two parts.

7. The lower endosperm nucleus divides once or twice, forming two or three free nuclei which enlarge enormously and seem to disintegrate when the embryo is mature.

8. The growth and curving of the embryo sac is practically all above the partition wall; and in this part the upper endosperm nucleus forms many small free cells, those aggregated in the lower part, above the partition wall, finally being surrounded by cell walls and forming a sort of cap over the tip of the cotyledon.

9. The pollen tube expands as it enters the embryo sac and passes down on one side past one of the synergids, which disappears at this time.

10. The two sperm nuclei both enter the embryo sac with the pollen tube, but only one leaves the tube and takes part in fertilizing the oosphere.

11. The sperm nucleus is nearly always seen with two very

distinct centrospheres preceding it as it passes through the tip of the tube.

12. When the sperm nucleus passes out of the tube, the apex of the tube appears to soften, and the sperm nucleus, with its centrospheres, appears to break out abruptly, leaving a distinct opening in the tip of the tube, the edges of which often appear ragged; and from this perforation cytoplasm is seen to escape after the sperm nucleus.

13. At the approach of the pollen tube the nucleus of the oosphere is greatly affected, being drawn out into a large bulge toward the approaching male cell. Sometimes two prominent centrospheres appear just on the top of this bulge.

14. Centrospheres appear in resting nuclei and in division stages, and just before the contact and during the fusion of the two sexual nuclei two pairs of centrospheres appear, which seem to fuse simultaneously with the sex nuclei.

15. The remaining synergid persists for a long time above and somewhat to one side of the vesicular suspensor cell, apparently in an active and healthy condition.

16. After fertilization the oospore pushes downward and divides by a transverse wall.

17. The second division of the pro-embryo is in the lower cell, also by a transverse wall. Of the three cells thus developed in acropetal order, the uppermost cell never divides again, but enlarges greatly, forming the vesicular suspensor cell; the lowest develops into the cotyledon, while the middle cell gives rise, by an indefinite number of divisions in basipetal order, to the stem apex, hypocotyl, root tip, and a few suspensor cells.

18. The cell divisions during the formation of the embryo do not occur in regular order, and though the succession of cells follows some general plan, there are frequently remarkable variations which must necessarily change the whole course of development.

19. The cotyledon is first differentiated, and next the stem apex, which develops from a lateral hypodermal cell in the first tier above the terminal cotyledon cell. The hypocotyl develops

from one or two tiers above the stem apex tier, while the root apex develops from an undetermined tier above the hypocotyl region.

20. Beyond the root apex a short suspensor of a single chain of cells, variable in number, connects the embryo with the large vesicular suspensor cell.

21. In the mature embryo the dermatogen, periblem, plerome, and calyptrogen are well differentiated, the plerome strand and periblem cylinder terminating in a single initial cell just within the calyptrogen layer.

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EXPLANATION OF PLATES XX–XXVI

PLATE XX.

FIG. 1. Section of a nectary showing the position of the secreting cells. × 90.

FIG. 2. Pollen mother cells in the mother star stage, with centrospheres at the poles. × 800.

FIG. 3. Pollen mother cell with two centrospheres at each pole. × 800.

FIG. 4. Tetrad stage. × 800.

FIG. 5. Microspore. × 800.

FIG. 6. Pollen grain with two nuclei; the generative nucleus has two centrospheres. × 800.

FIG. 7. Pollen grain with the generative nucleus divided into the two sperm nuclei. × 800.

FIGS. 8 and 9. Mature pollen grains. × 800.

FIG. 10. Embryo sac with four nuclei. × 800.

FIG. 11. Mature eight-celled embryo sac; the antipodals are already surrounded by definite cell walls. × 800.

PLATE XXI.

FIG. 12. Outline sketch of mature eight-celled embryo sac, showing relative size of the nuclei. × 600.

FIG. 13. Conjugating polar nuclei, showing one pair of centrospheres. × 600.

FIG. 14. Embryo sac with the polar nuclei partly fused; the antipodal cells are without walls. × 600.

FIG. 15. Definitive nucleus nearly complete, with a pair of fused centrospheres on opposite sides; the two nucleoli are still distinct. × 600.

FIG. 16. Definitive nucleus with three nucleoli distinct, and two centrospheres on opposite sides. × 600.

FIG. 17. Definitive nucleus with two large nucleoli apparently fusing. × 600.

FIG. 18. Definitive nucleus with one small nucleolus and two large fusing nucleoli. × 600.

FIG. 19. Embryo sac showing one synergid, the oospore, the definitive nucleus, and two antipodals; the definitive nucleus has but one large nucleolus. × 600.

FIG. 20. Upper end of an embryo sac, showing the arrangement of the egg apparatus. × 600.

FIG. 21. Upper end of embryo sac with pollen tube entering; the oosphere nucleus with two prominent centrospheres. × 600.

FIG. 22. Upper end of an embryo sac with pollen tube; one sperm nucleus in the tip of the tube preceded by two centrospheres. × 600.

FIG. 23. Pollen tube with a sperm nucleus at the tip preceded by two centrospheres. × 600.

PLATE XXII.

FIG. 24. Upper end of embryo sac with pollen tube; two sperm nuclei in the tube, the one at the tip preceded by two centrospheres. × 600.

FIG. 25. Embryo sac with definitive nucleus, one antipodal, one synergid, oosphere, and pollen tube with two sperm nuclei; several granules between the oosphere nucleus and the sperm nucleus at the tip of the tube. × 600.

FIG. 26. Upper end of embryo sac with pollen tube. × 600.

FIG. 27. Upper end of embryo sac; the lower sperm nucleus is just leaving the tube, and between it and the oosphere is a mass of granular protoplasm. × 600.

FIG. 28. Upper end of embryo sac; the sperm nucleus with prominent centrospheres has left the tube and is approaching the oosphere. × 600.

FIG. 29. Part of an embryo sac with definitive nucleus, oosphere, and pollen tube; the oosphere nucleus is greatly bulged out on the side toward the sperm nucleus; sperm nucleus just leaving the tube. × 600.

FIG. 30. Upper end of embryo sac; the sperm nucleus has just left the pollen tube, which shows a perforation at the tip from which protoplasm is escaping; four very prominent centrospheres appear at the two angles of the approaching sexual nuclei. × 1125.

FIG. 31. A little later stage than *fig. 30;* the sexual nuclei are in contact, and two pairs of centrospheres appear above and below; one of the synergids lies in front of the tube, the other has disappeared. × 1125.

FIG. 32. Upper end of embryo sac after fertilization, with large spherical oospore nucleus, and pollen tube containing the remaining sperm nucleus. × 1125.

FIG. 33. Oospore beginning to descend; the pollen tube is beginning to disappear; above the oospore lies the remaining synergid. × 600.

FIG. 34. A cell from the tip of a young embryo with nucleus in the daughter skein stage: two large centrospheres at each pole. × 850.

PLATE XXIII.

FIG. 35. Upper end of embryo sac with oospore and synergid. × 400.

FIG. 36. Embryo sac with a two-celled pro-embryo; two endosperm nuclei separated by a distinct cell wall stretching across the sac, and three antipodal cells. × 400.

FIG. 37. Lower end of embryo sac, a little later than *fig. 36*, showing the position of the first two endosperm cells and the cell wall between them. × 400.

FIG. 38. Embryo sac with a two-celled pro-embryo and two endosperm cells separated by a cell wall. × 400.

FIG. 39. About the same stage as *fig. 38;* the upper endosperm nucleus is dividing. × 260.

FIG. 40. Lower end of an embryo sac which contains a nine-celled pro-embryo; the upper endosperm nucleus has divided into many free cells while the lower remains undivided; at the base two antipodals. × 400.

FIG. 41. Complete embryo sac with a nine-celled pro-embryo containing a number of comparatively small free endosperm nuclei; the endosperm nucleus below the partition wall has divided into two nuclei which have greatly enlarged; two antipodals appear at the lower end of the sac. × 66.

FIG. 42. Lower end of an embryo sac containing a ten-celled pro-embryo; the lower endosperm nucleus has divided into two; the antipodal region with very thick walls retaining its original size and contour. × 216.

FIG. 43. Lower end of an embryo sac in which the lower endosperm nucleus has divided into three. × 400.

FIG. 44. Lower end of an embryo sac with embryo at the stage represented in *fig. 72;* the antipodal region is still distinct and contains the three original nuclei; the lower endosperm nucleus has remained undivided; above the partition wall the sac is filled for some distance with endosperm tissue produced by the upper endosperm nucleus. × 216.

FIG. 45. Secreting cells from a nectary showing the appearance of the cytoplasm and nuclei. × 400.

PLATE XXIV.

FIG. 46. Three-celled pro-embryo with synergid (*s*) on the side of the vesicular cell *a*; middle cell (*b*) dividing. × 400.

FIG. 47. Three-celled pro-embryo with terminal cell dividing. × 400.

FIG. 48. Four-celled pro-embryo with synergid (*s*) beside the vesicular cell; the free nucleus is endosperm. × 400.

FIG. 49. Four-celled pro-embryo with terminal cell (*c*) dividing. × 400.

FIG. 50. Five-celled pro-embryo. × 400.

FIG. 51. Five-celled pro-embryo with the two middle cells dividing. × 400.

FIG. 52. Five-celled pro-embryo with the cells in a single row. × 400.

FIG. 53. Six-celled pro-embryo with synergid above the vesicular cell. × 216.

FIG. 54. Six-celled pro-embryo with synergid. × 400.

FIG. 55. Seven-celled pro-embryo with synergid above the vesicular cell; the two lowest cells each with a cell beneath, which does not appear in the figure. × 400.

FIG. 56. Seven-celled pro-embryo; the free nuclei are endosperm. × 216.

FIG. 57. Seven-celled pro-embryo with one of the cells at the tip dividing. × 400.

FIG. 58. Upper end of embryo sac with a nine-celled pro-embryo; the nucleus above the vesicular cell belongs to the synergid. × 216.

FIG. 59. Ten-celled pro-embryo. × 400.

FIG. 60. Ten-celled pro-embryo; the two cells not shown belong to lowest tier. × 216.

FIG. 61. Eleven-celled pro-embryo with synergid. × 400.

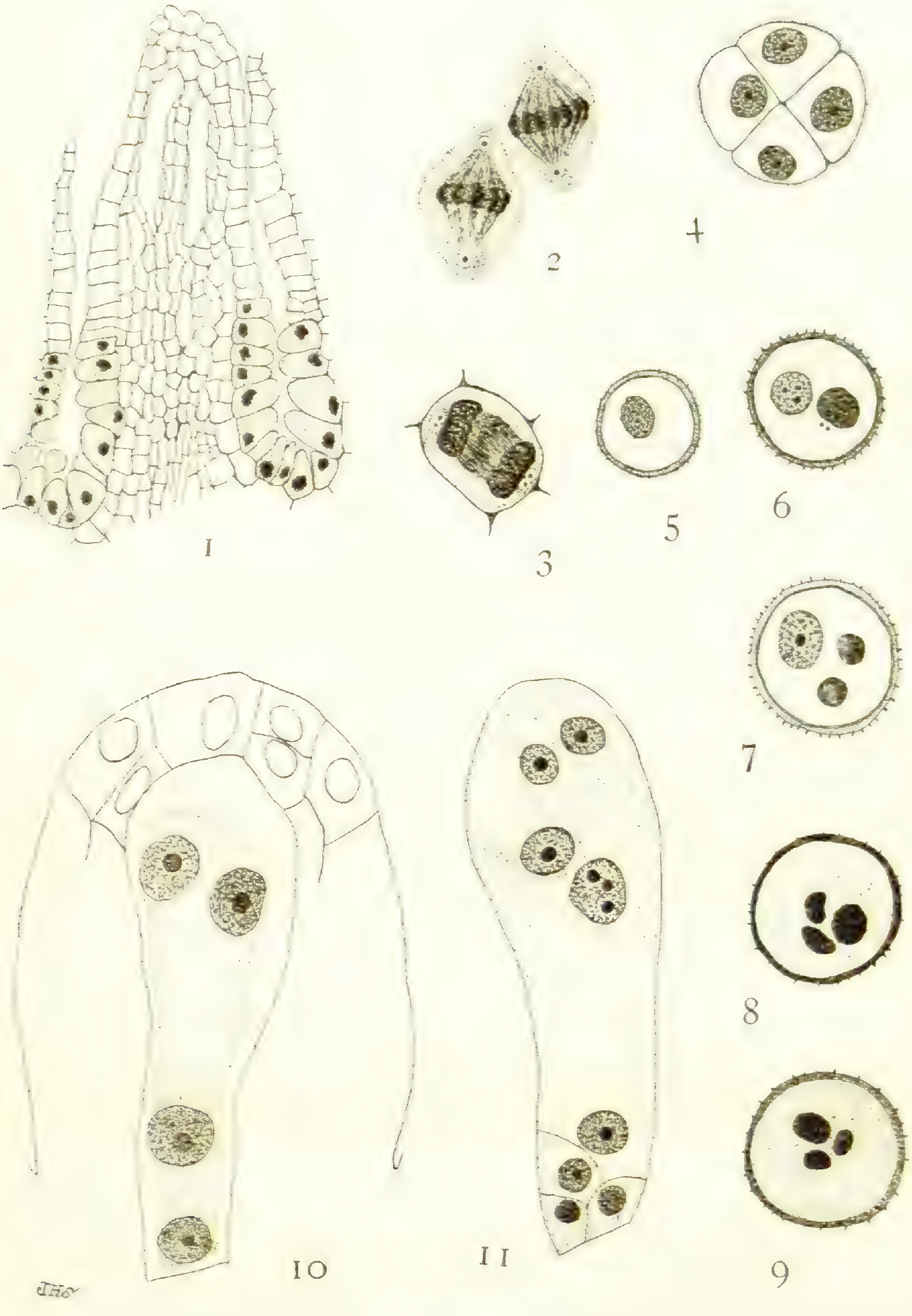
PLATE XXV.

FIG. 62. Twelve-celled pro-embryo with synergid; two cells in the lowest tier not shown. × 400.

FIG. 63. Eleven-celled pro-embryo; the two cells not shown belong to lowest tier. × 400.

FIG. 64. Embryo with dermatogen cut off from the octant which forms the cotyledon. × 260.

FIG. 65. Embryo showing the appearance of the synergid and vesicular cell at this stage, and further development of the dermatogen. × 400.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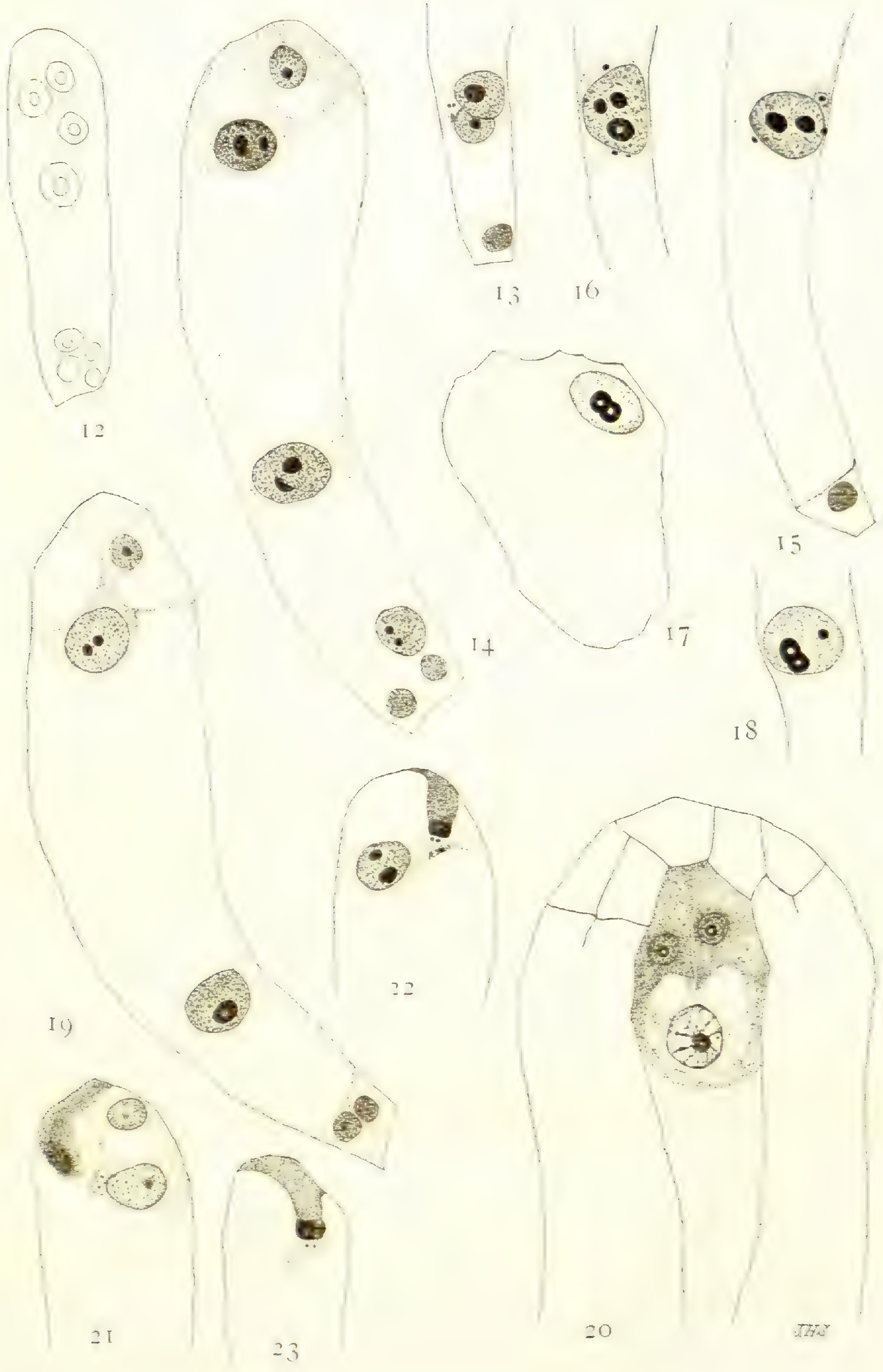
SCHAFFNER on SAGITTARIA VARIABILIS.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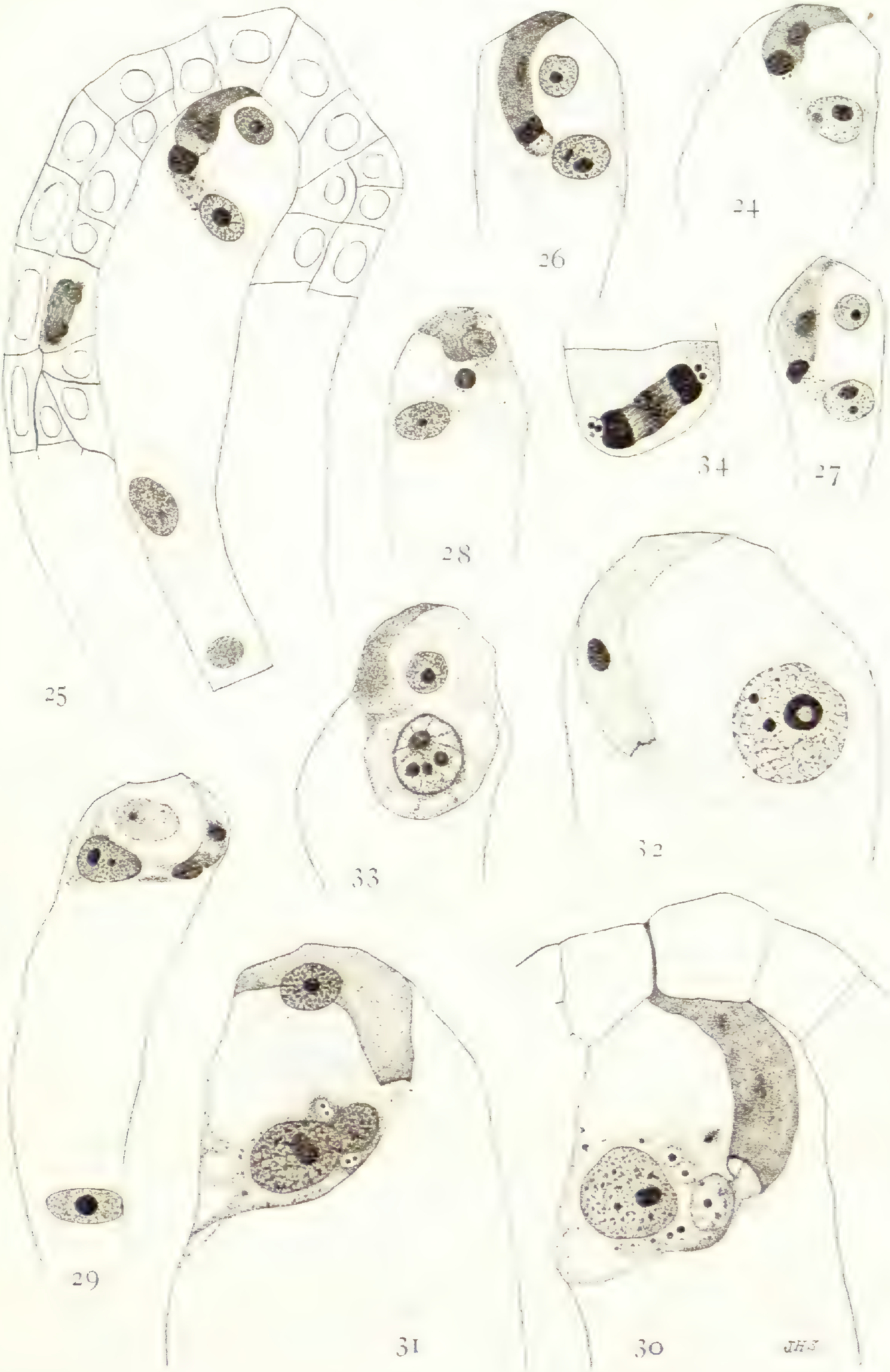
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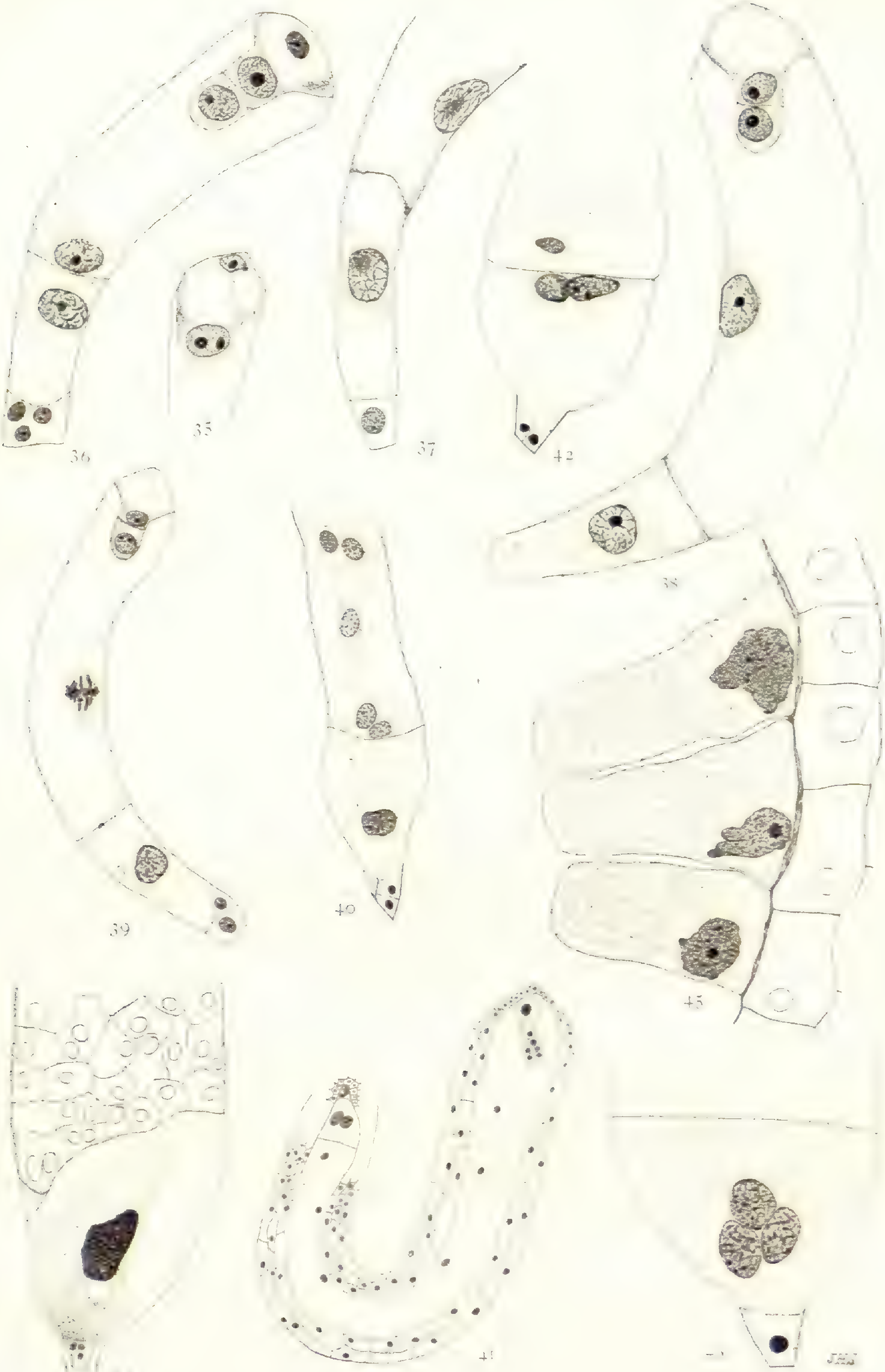
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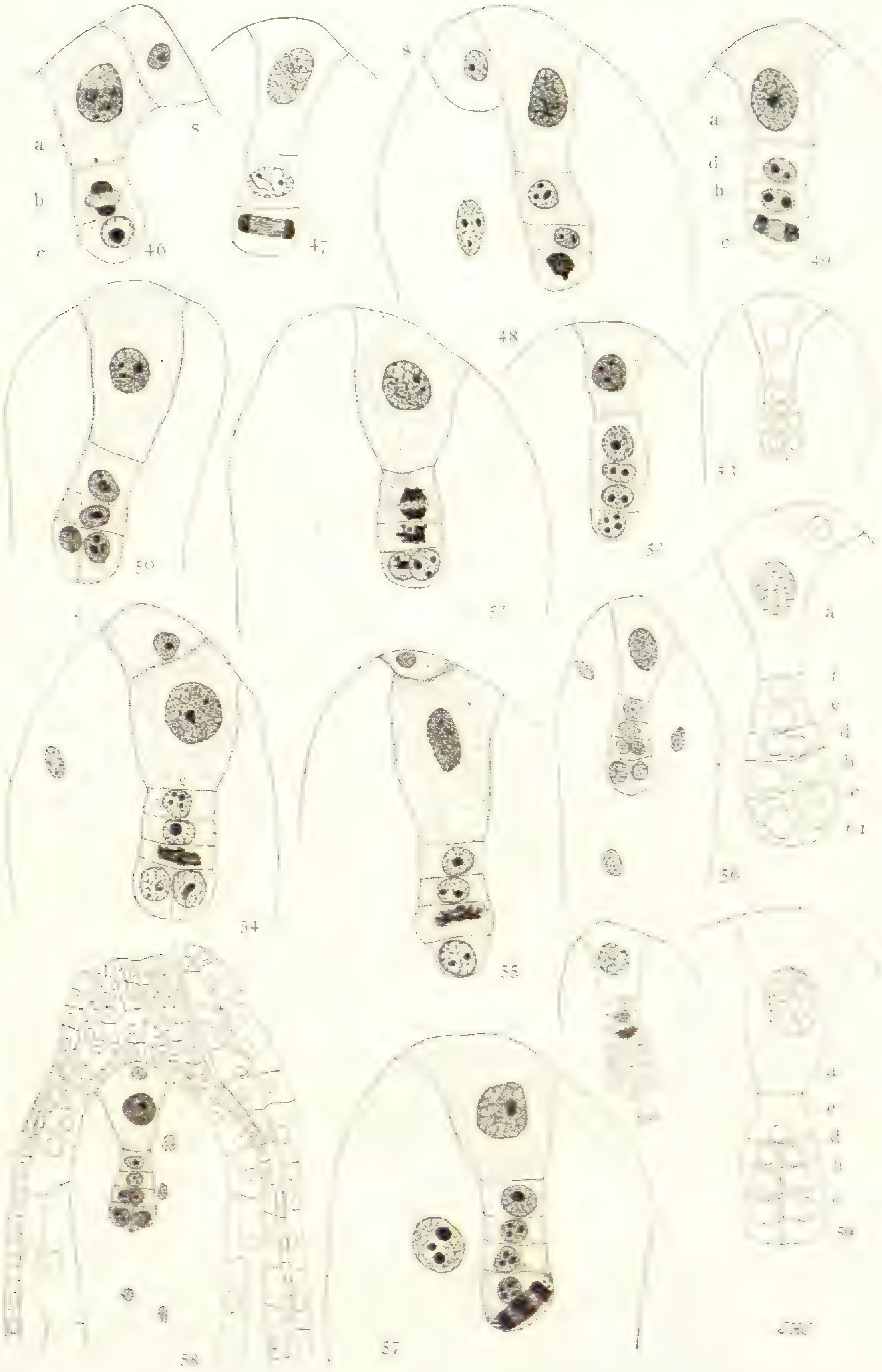
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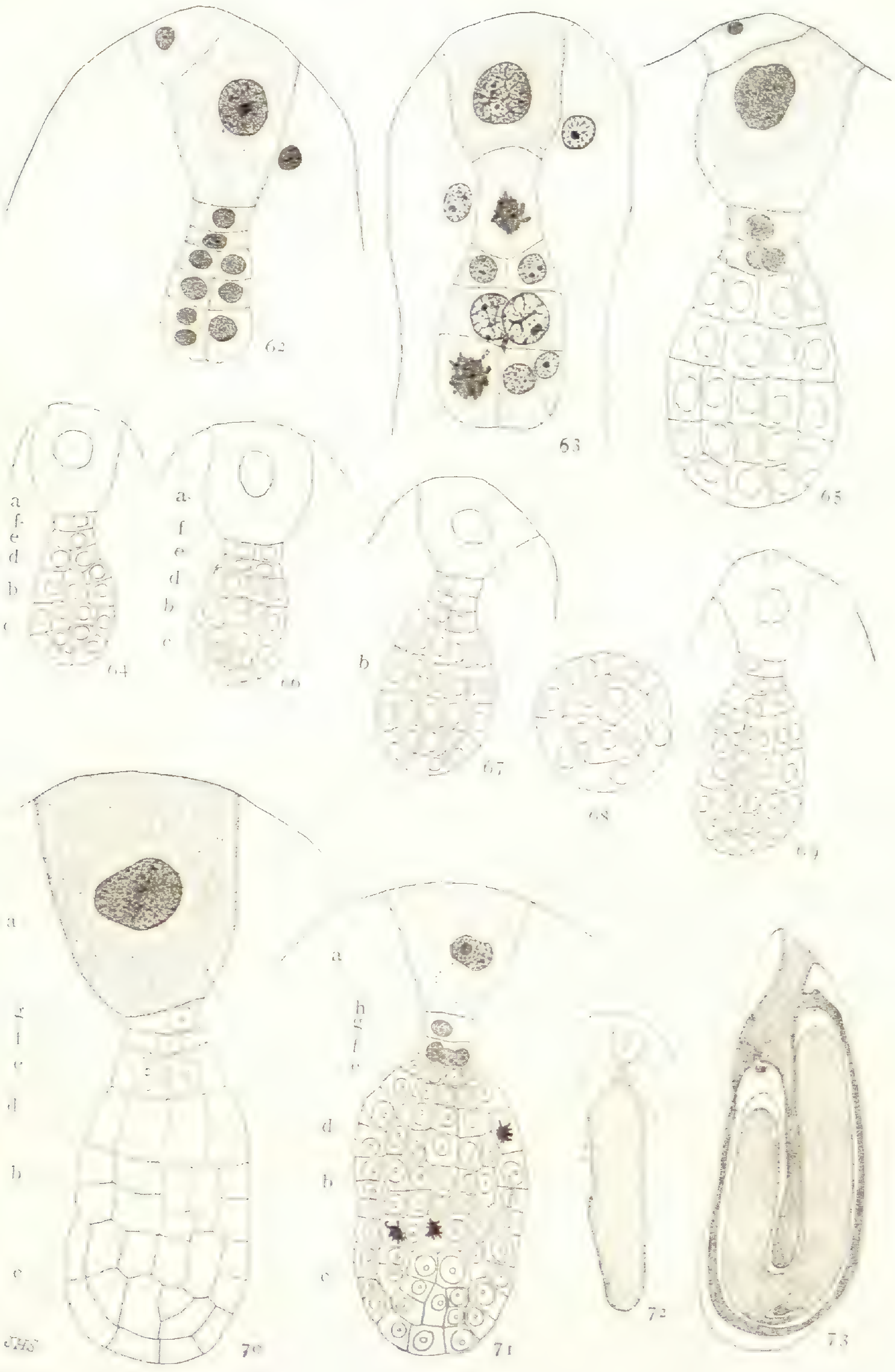
SCHAFFNER on SAGITTARIA VARIABILIS.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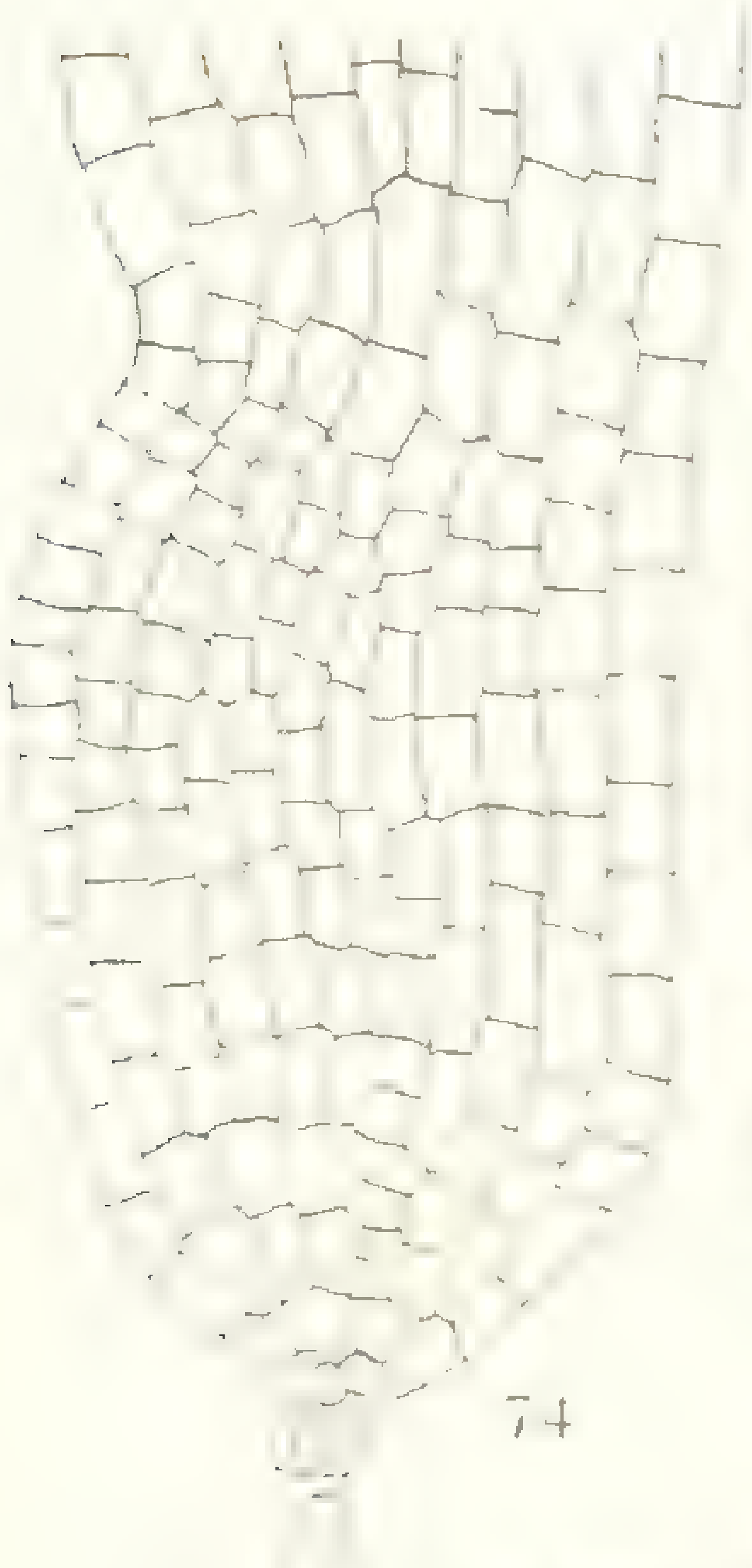
SCHAFFNER on SAGITTARIA VARIABILIS.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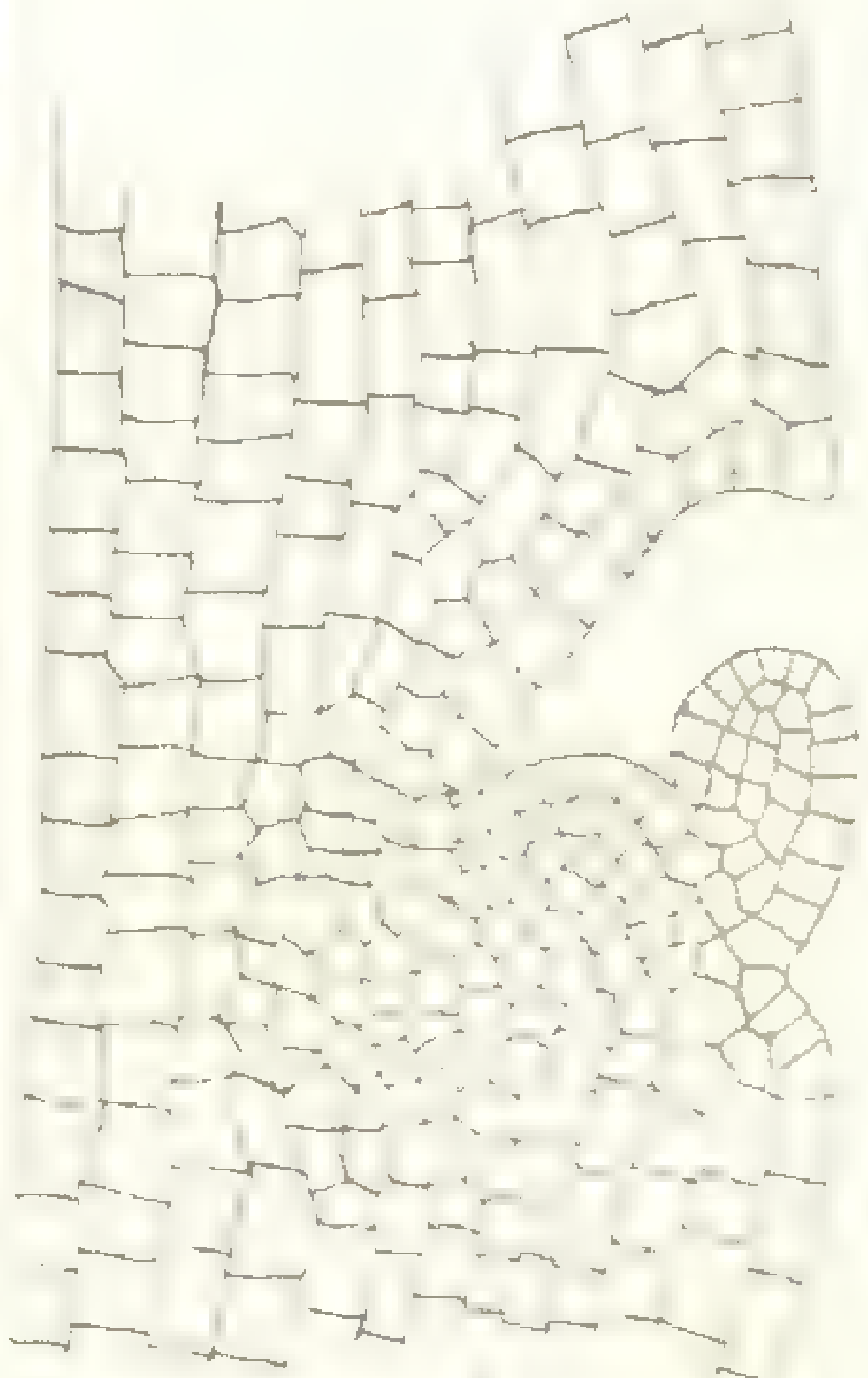
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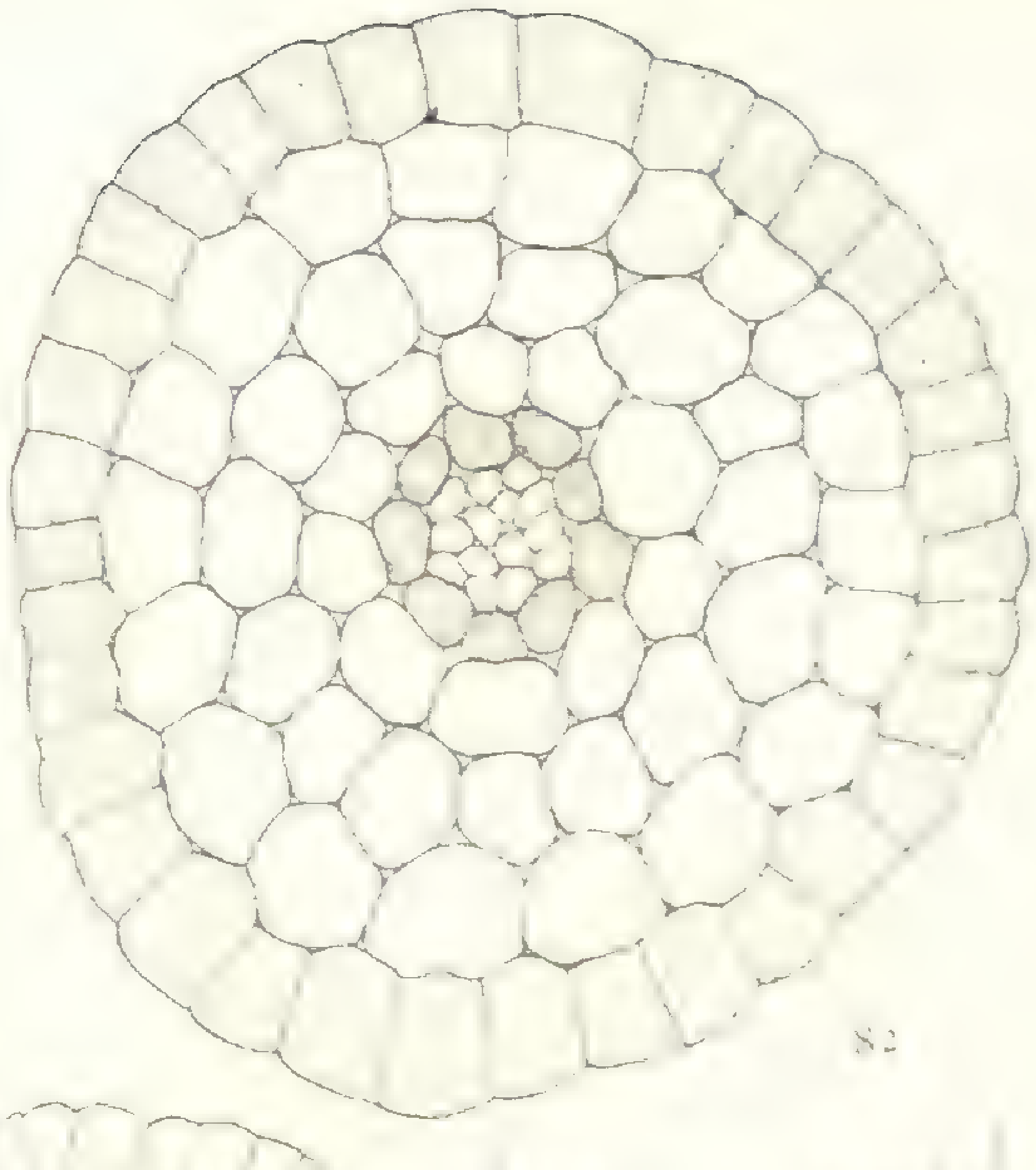
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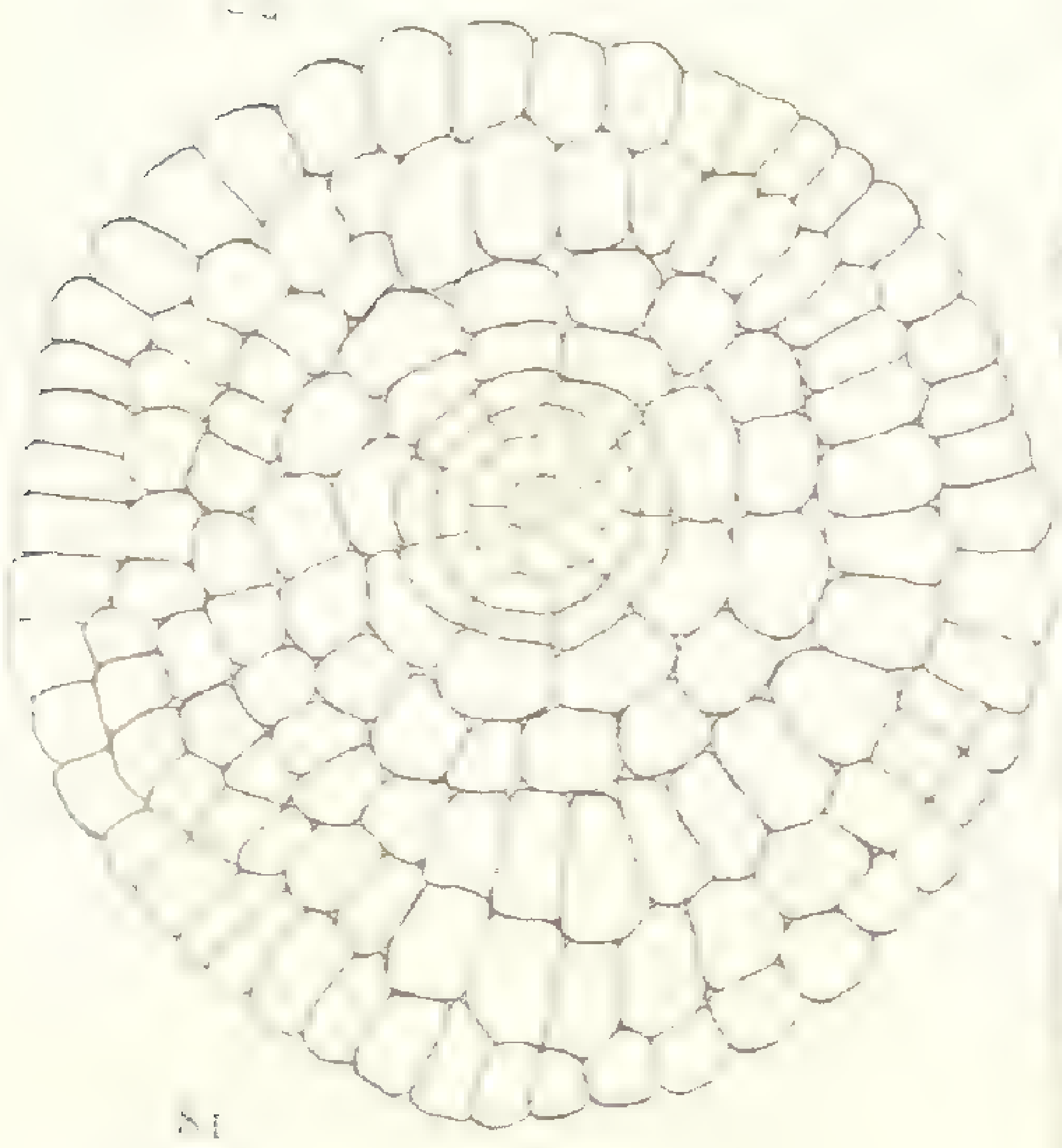
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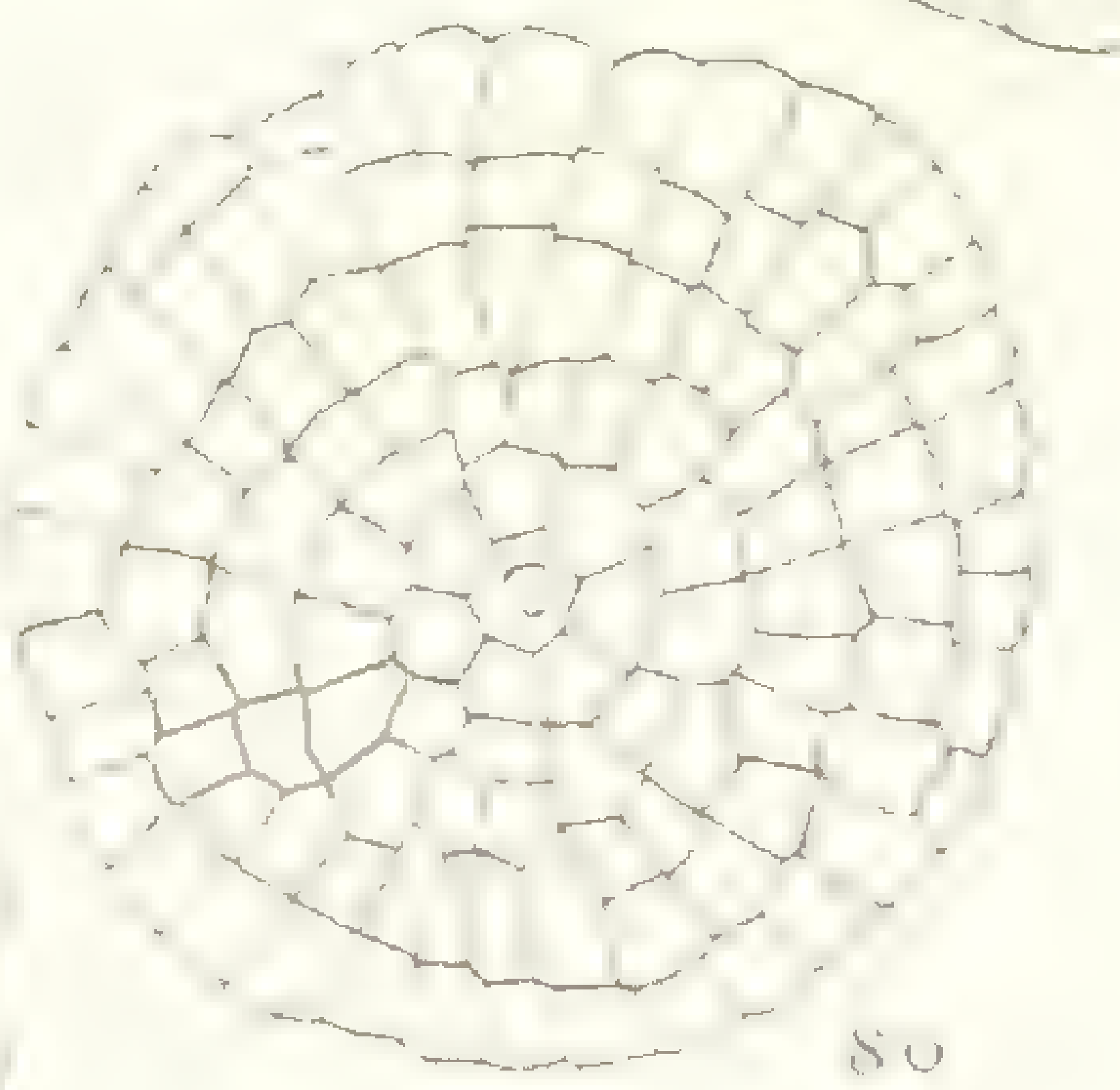
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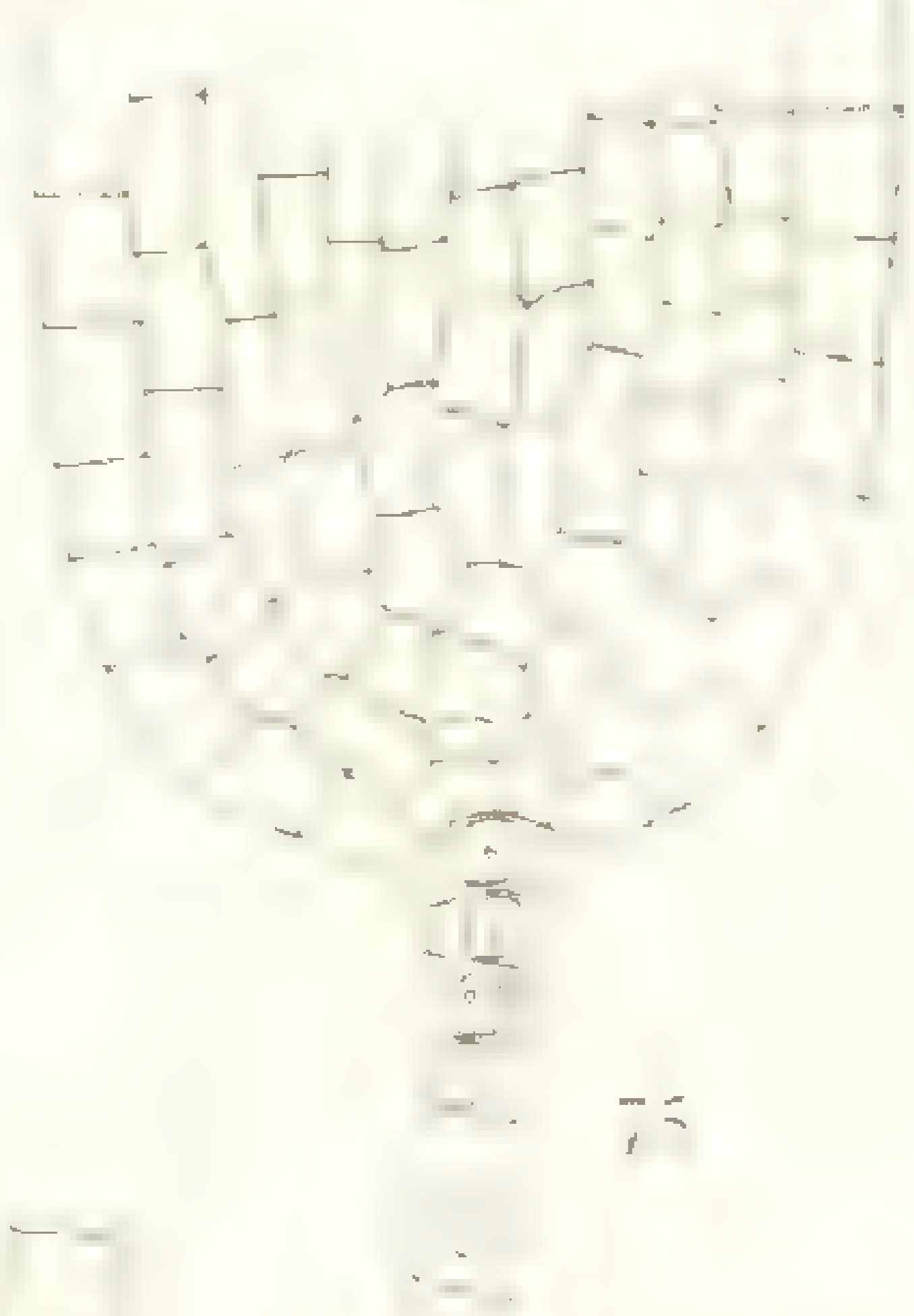
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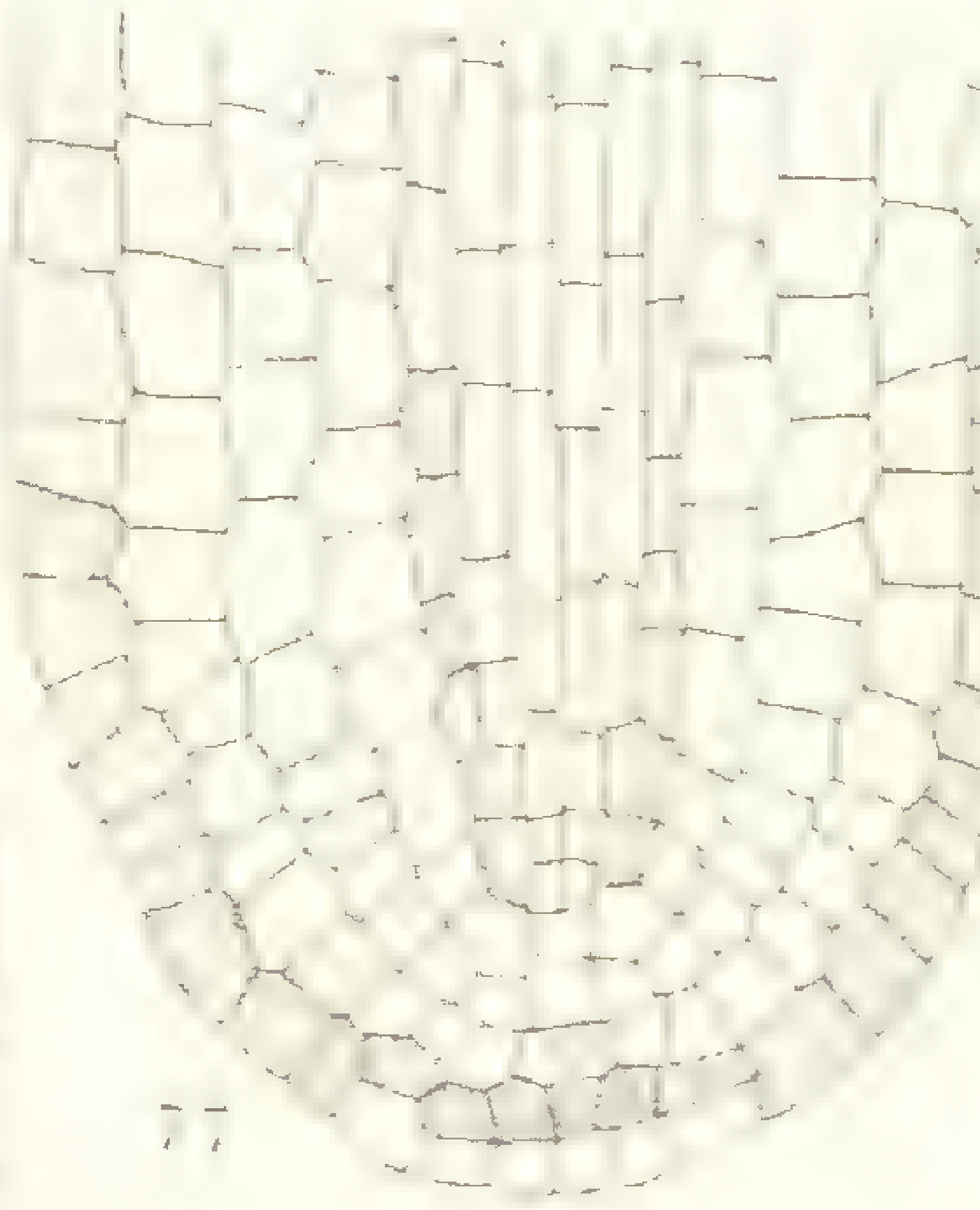
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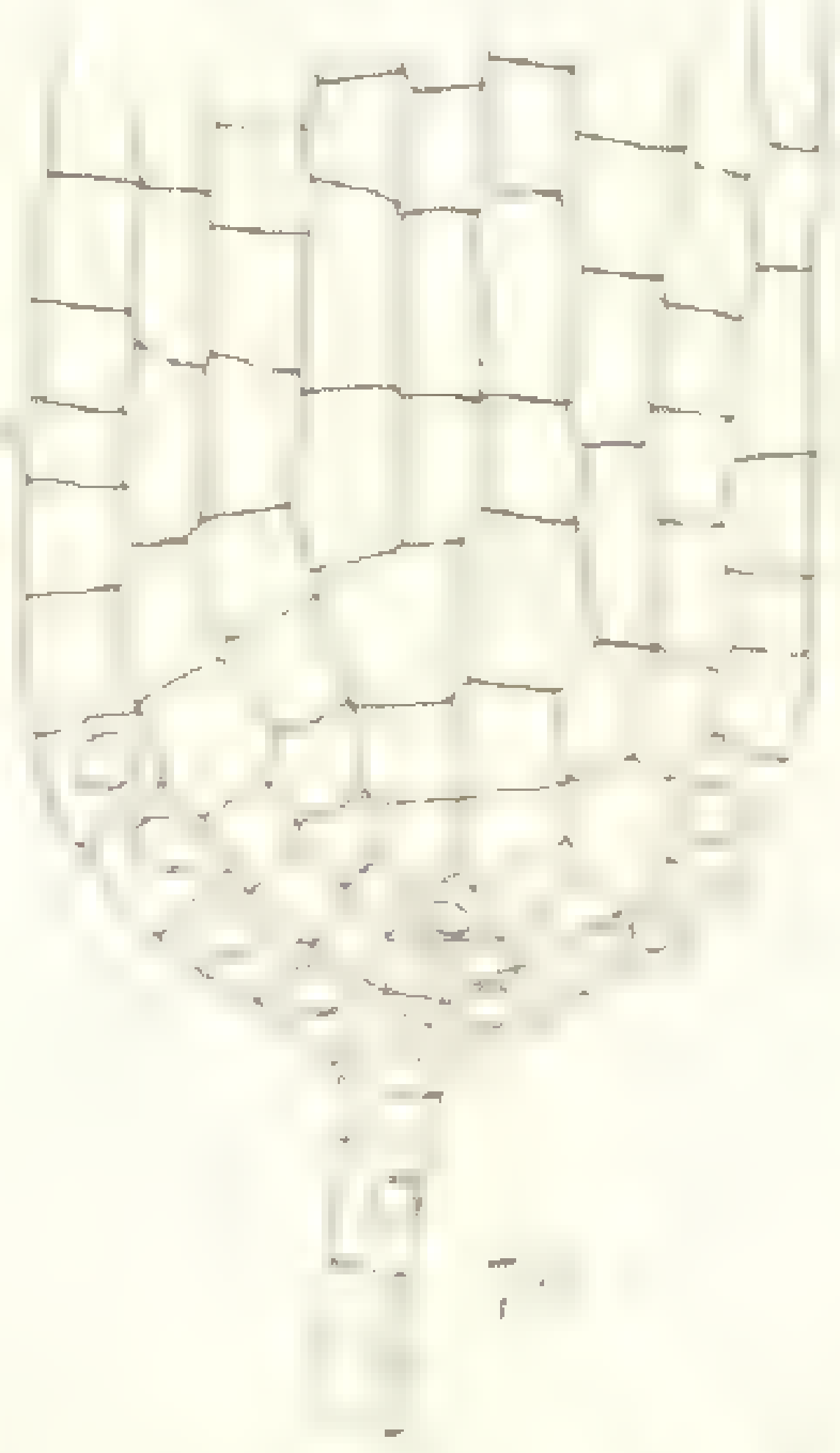
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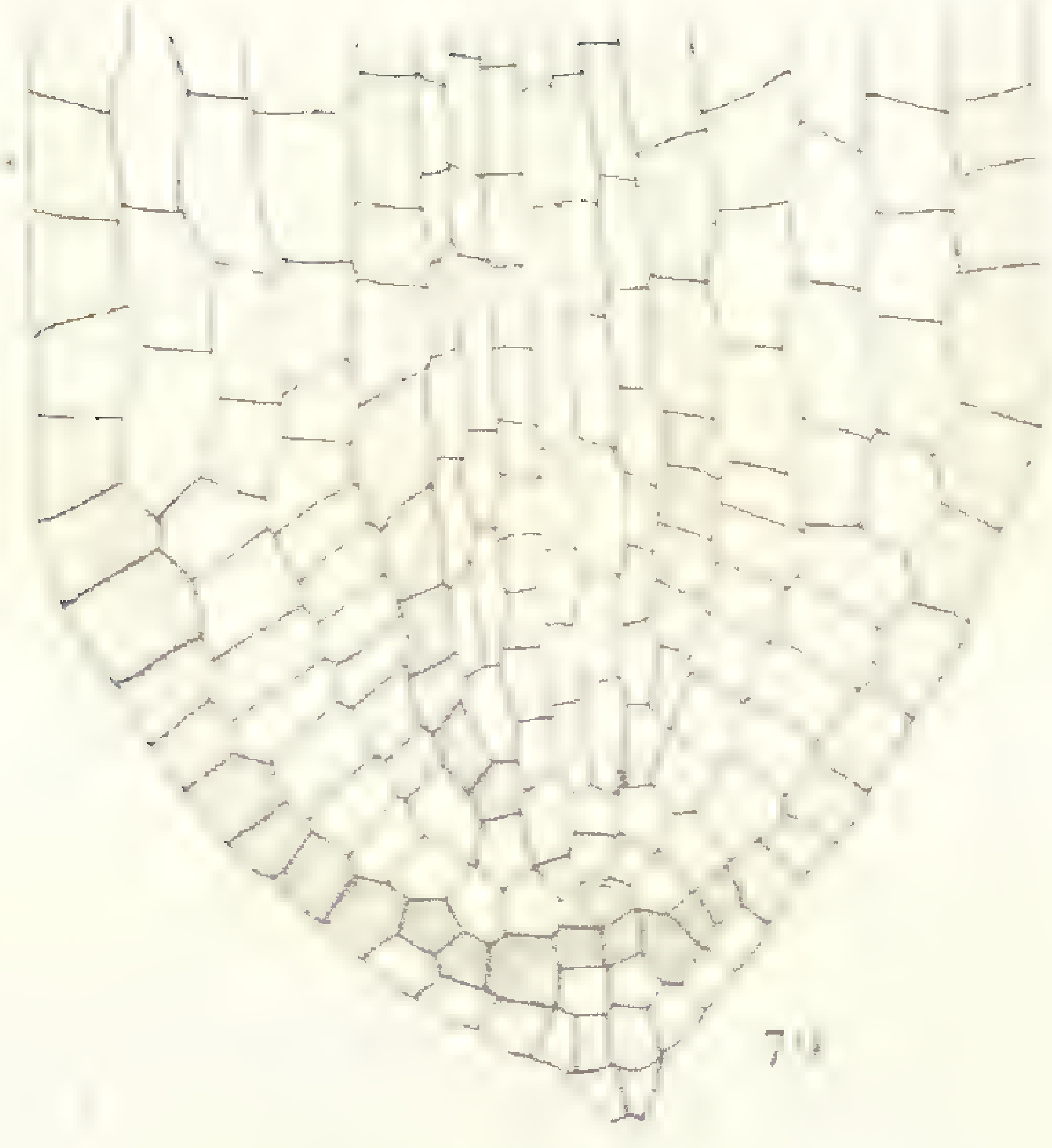
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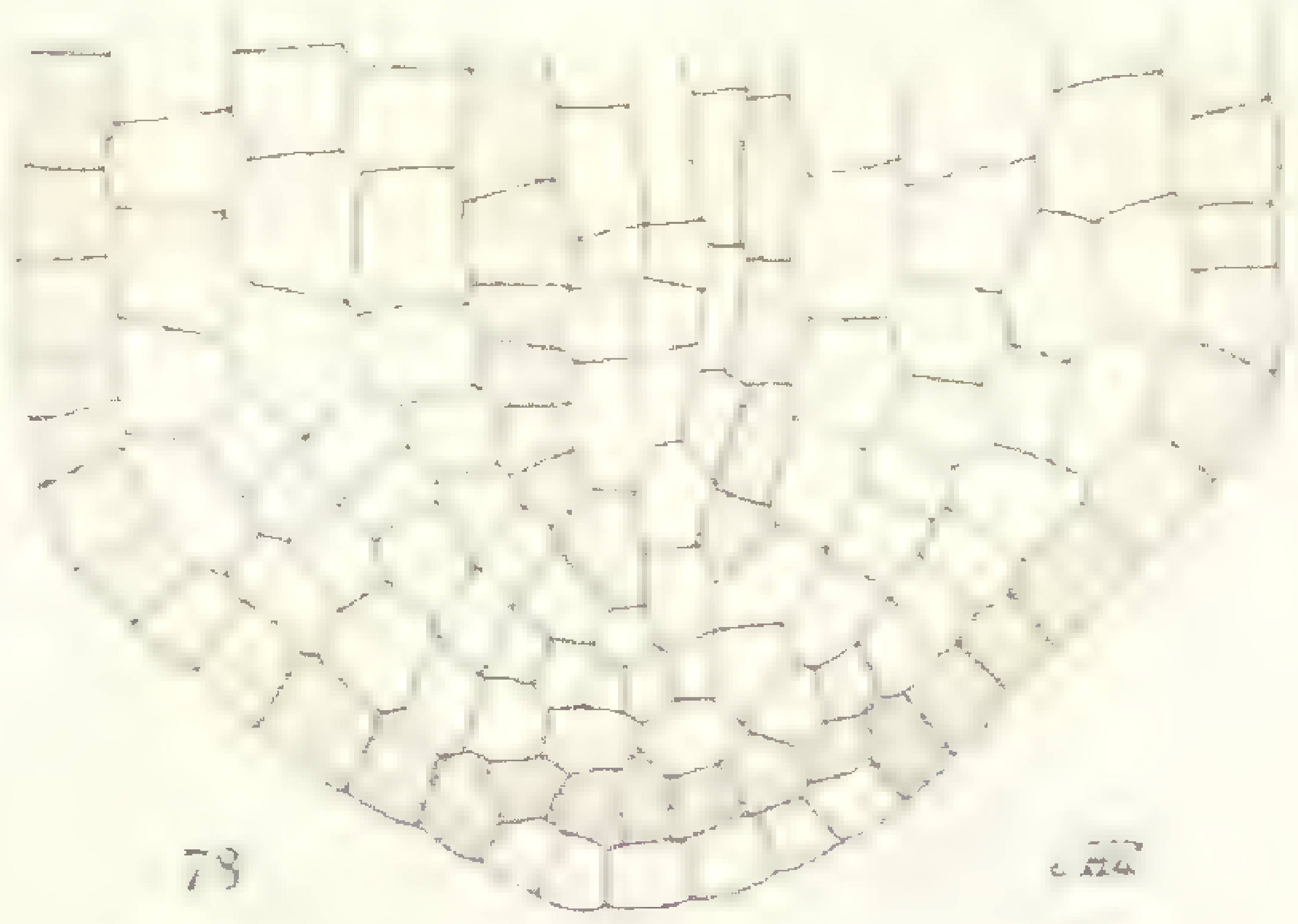
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SCHAFFNER on SAGITTARIA VARIABILIS.

FIG. 66. Embryo showing exceptional suspensor development; the cells below the vesicular cell have divided longitudinally. × 260.

FIG. 67. Embryo showing origin of the stem apex by transverse division of a hypodermal cell in tier *b*. × 260.

FIG. 68. Transverse section through the young cotyledon of an embryo at the same stage as *fig. 67*. × 400.

FIG. 69. Embryo showing further differentiation in the development of the stem tip by transverse division of the dermal cell. × 260.

FIG. 70. Embryo a little older than *fig. 69*, showing the glandular appearance of the vesicular cell *a*. × 400.

FIG. 71. Embryo showing further development of the cotyledon (*c*), stem apex (*b*), and hypocotyl (*d*). × 260.

FIG. 72. Embryo more advanced, with two suspensor cells below the vesicular cell. × 66.

FIG. 73. Section of mature ovule showing the position of the embryo, the cap of endosperm beyond the tip of the cotyledon, the fragments of the lower endosperm cells, and the original antipodal region projecting beyond the embryo sac somewhat like a vermiform appendix. × 26.

PLATE XXVI.

FIG. 74. Part of an embryo, showing the beginning of the differentiation of the apex of the root. × 216.

FIG. 75. Root tip of an embryo showing a suspensor with more than five cells. × 260.

FIG. 76. Section of the root tip of an embryo showing the differentiation of a single hypodermal cell into an initial cell. × 216.

FIG. 77. Section of root tip showing the distinct differentiation of dermatogen, periblem, plerome, and calyptrogen, and also the initial cell. × 216.

FIG. 78. Section of a root tip about the same stage as *fig. 77*, but with less regularity in the arrangement of the cells. × 216.

FIG. 79. Section of the root tip of a nearly mature embryo, showing the arrangement of the tissues. × 216.

FIG. 80. Transverse section through the apex of the root of a mature embryo, showing the single initial cell at the growing point. × 216.

FIG. 81. Transverse section a little beyond that shown in *fig. 80*, showing differentiation of the plerome cylinder. × 216.

FIG. 82. Transverse section through the hypocotyl, showing the arrangement of the dermatogen, periblem, and plerome. × 216.

FIG. 83. Longitudinal section through the apex of the stem in a mature embryo. × 140.

PRELIMINARY REVISION OF THE NORTH AMERICAN SPECIES OF CHRYSOSPLENIUM.[1]

J. N. ROSE.

FOUR species of Chrysosplenium are here recognized as belonging to North America. One of these, although it has been long represented in our larger herbaria, has never before been published; another (*C. tetrandrum*) has been considered a variety of *C. alternifolium* by recent monographers. After the examination of much material I have been forced to restore it to specific rank. The name *C. glechomaefolium* of Nuttall must give place to the older varietal name *Scouleri* of Hooker.

The genus is naturally separated into two groups by the leaves, one having them opposite and the other alternate. In America we have two species in each group; of the opposite-leaved group one species is western and one eastern ; of the alternate leaved group one species is known only from the Pribilof islands, while the other is high northern, but extends in the Rocky mountains as far south as Colorado, with an isolated form or variety in Iowa.

Although not found in America, *C. alternifolium* is included in the subjoined key on account of its confusion with *C. tetrandrum*.

* *Leaves all alternate.*

+ *Rootstock wanting: stolons slender: flowers yellow: disk inconspicuous or wanting: seeds many.*

++ *Stamens 8: leaves large, dull, veined, thin, spotted.*

CHRYSOSPLENIUM ALTERNIFOLIUM L. Sp. 1: 398. 1753.

Stems 5 to 15^{cm} high, 1 to 3-leaved: leaves thin, veined; radical leaves reniform, cordate at base, the sinus often closed,

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[1] Published by permission of the Acting Assistant Secretary, Smithsonian Institution, in charge of the U. S. National Museum.

15 to 36$^{\mathrm{mm}}$ wide, crenations 6 to 15, sometimes overlapping, broad and truncate or retuse, dull above, pale beneath: cells of leaves and calyx generally developing brown bodies giving the appearance of pellucid dots: stamens 8: seeds indefinite.

Europe and Asia.

++ ++ *Stamens 4: leaves minute, shining, indistinctly veined, not spotted.*

CHRYSOSPLENIUM TETRANDRUM Fries, Bot. Notis. 193. 1858.

Chrysosplenium alternifolium tetrandrum Lund, Bull. Acad. Sci. St. Petersb. **23**: 343. 1877.

Stems 1.2 to 7.5$^{\mathrm{cm}}$ high, very slender, 1 to 3-leaved: leaves thickish, with indistinct veins; radical leaves very small, 4 to 11$^{\mathrm{mm}}$ wide, crenations 3 to 7, more or less rounded, shining above, paler beneath: cells of leaves developing no dark bodies: stamens 4, opposite the sepals: seeds small, numerous (sometimes 50 or more).

Arctic regions. In America as far south as Colorado.

In the United States there are only two stations recorded for this species. One of these is in Colorado, where the plant was collected by Hall and Harbour in 1862 (no. 576). The plant, curiously enough, has not been found since. The other locality is at Decorah, Iowa, where it has been collected a number of times by Professor E. W. D. Holway. This latter form may yet prove distinct. It is somewhat larger, with slightly different leaves, and with six or seven stamens.

+ + *Rootstock thick: stolons wanting: flowers reddish: disk prominent: seeds few.*

Chrysosplenium Beringianum Rose, sp. nov.

Rootstock 2.5 to 5$^{\mathrm{cm}}$ long (?), creeping, sending off many long fibrous roots; radical leaves and stems several, spreading and forming a dense rosette: radical leaves small; petiole slender, 1.3 to 4.5$^{\mathrm{cm}}$ long, broader at base, the margins (especially below) ciliate with long purplish hairs; blade reniform, 6 to 11$^{\mathrm{mm}}$ broad, 4 to 5-crenate, crenations sometimes gland-tipped, thickish, pale and glabrous below, dark green and glabrous or somewhat pilose above: stem 2.5 to 5$^{\mathrm{cm}}$ high, naked or bearing a single leaf below the involucre; involucral leaves several, entire or 3-crenate, extending beyond the flowers: calyx 5 to 6^{mm} broad, 4-lobed, purplish or becoming so; sepals very broad, nearly orbicular, rounded at apex; disk very prominent, strongly 8-lobed; fruiting calyx turbinate, 1^{mm} high: capsule 2-horned, 6 to 10-seeded; seeds oblong, 0.5^{mm} long, shining, delicately reticulated.

Collected by C. Hart Merriam on St Paul Island, August 7, 1891, and described in the Proceedings of the Biological Society without specific name; since collected on the same island by Mr. F. W. True and D. W. Prentiss, Jr., August 6, 1895 (no. 66), and by Mr. James M. Macoun, July 6, 1892, and 1896; subsequently by Mr. Beaman on St. Paul, and one specimen by Dr. Dall in "Alaska."

This species has been confused with *C. alternifolium*, from which it appears to be abundantly distinct. *C. alternifolium* differs in its habit in lacking the thickish rootstocks and possessing only slender stolons and filiform roots; in its larger, usually much larger leaves, more numerous and generally double crenations, the smaller indentations containing a gland, or when simply crenate each crenation gland-tipped, thin, membranaceous in texture (when dry), paler in color; petioles with margins usually glabrous but sometimes ciliate with a few white hairs.

Our form, which resembles *C. tetrandrum* in the size and shape of the leaves, has 8 stamens instead of 4, purple instead of greenish flowers, larger and definite seeds (6 to 10 instead of 30 to 50), stronger-lobed disk, and apparently differs also in its habit.

In the study of this species I have had all the material from the Gray Herbarium, Columbia College Herbarium, Herbarium of the Natural History Survey of Canada, Herbarium of the Philadelphia Academy of Science, and National Herbarium. I also sent specimens to Kew and received the assurance that it "differs from everything else at Kew." Mr. James M. Macoun has also studied it in connection with the material at Kew and the British Museum, but finds nothing like it.

This species will be redescribed and figured in the forthcoming Catalogue of the Plants of the Pribilof Islands by Mr. James Macoun, which will appear in the formal report of the Fur Seal Commission now in press.

* * *Lower leaves all opposite.*

+ *Leaves orbicular, abruptly petioled, with few coarse crenations: flowers sessile or nearly so: eastern.*

CHRYSOSPLENIUM AMERICANUM Schwein. Hook. Fl. Bor. Am. **1**: 242. 1834.

Canada and Minnesota southward.

+ + *Leaves orbicular, more or less cuneate at base, strongly and abundantly crenate: flowers clearly pedicelled: western.*

Chrysosplenium Scouleri (Hook.) Rose.

Chrysosplenium oppositifolium Scouleri Hook. Fl. Bor. Amer. **1**: 242. 1834.

Chrysosplenium glechomaefolium Nutt. in Torr. & Gr. Fl. **1**: 589. 1840.

Oregon and Washington.

U. S. NATIONAL MUSEUM.

BRIEFER ARTICLES.

FACILITIES FOR BOTANICAL RESEARCH AT THE NAPLES ZOOLOGICAL STATION.

(WITH PLATE XXVII)

IT was my good fortune to be able to occupy the Smithsonian table at the Naples Zoological Station for three months during the spring of 1896.[1] I had received some time before a printed circular from the director, Professor Dohrn, telling what apparatus I would need to bring and how best to bring it, and in accordance with the wish therein expressed I had written the station stating when I should arrive and what algæ I should desire for study. On the morning of my arrival I visited the station, introduced myself, and found a room prepared for me, with several trays full of interesting algæ on the table. I was put in care of an employé, who helped me to find suitable lodgings, and within three hours I had my baggage moved into them and was installed ready for work in my laboratory at the station. The common reagents for microscopic work had been placed on my table, and such special fixatives and stains as I needed were promptly prepared for me by the chemist in charge of supplies. As I expected to do cytological work I asked for a paraffin oven, which was at once installed. Wall tables, a microscopic work desk, and aquaria were ready, and within two days I had various species of algæ growing vigorously. Almost every want of the investigator is anticipated and provided for. Servants are ready to assist in any heavy work, keep the fire going when the weather is chilly, and clean up the room at night. The abundant and varied facilities for collecting, ranging from a diving suit (found very useful by Berthold in his studies on the distribution of algæ in the gulf) to a small steam yacht, the "Johannes Müller," are at the disposal of the investigator. Cav. Lo Bianco, whose beautiful museum specimens are widely known, has an incredibly wide knowledge of forms and is always ready to assist in procuring any desired species. The library, very rich in zoological and general biological works, is well indexed and is open every day until six p. m. The station buildings, open until nine p. m., are beautiful three-story white structures. On the ground floor of the main building is the unrivaled aquarium, which is of great interest to all tourists, rich as the city is in other attractions. The cut here given (*fig. 1*) shows a view from the southwest. The alcoves along the south side of the library may be seen to the right. The three large windows in the middle of the west front are those of the botanical rooms.

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[1] I wish here to thank Secretary S. P. Langley and the committee in charge of appointments to the Naples table for this privilege.

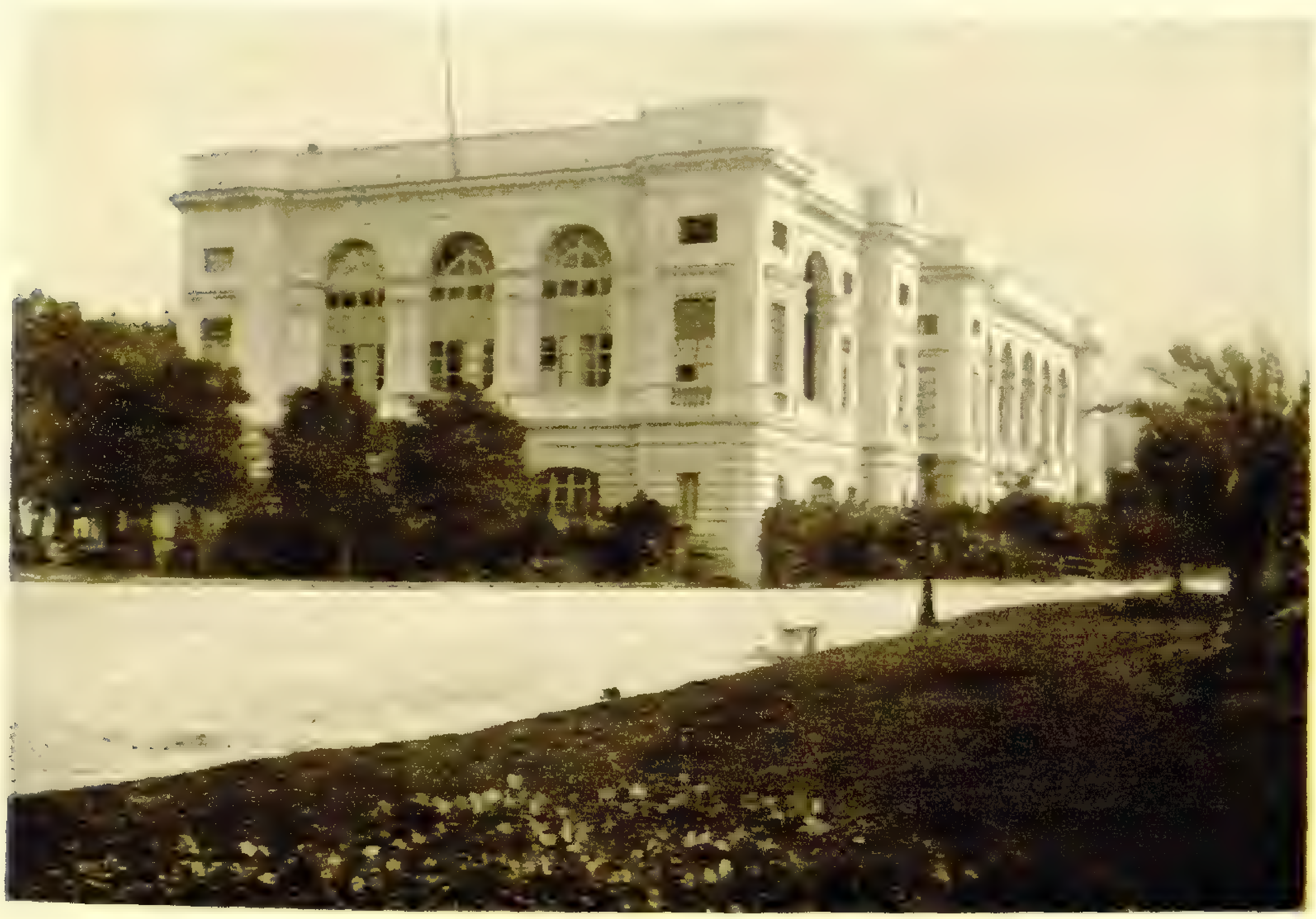

FIG. 1. View of the Naples Zoological Station from the southwest.

The flora and fauna of the gulf of Naples are exceedingly rich and many of the best collecting grounds for the botanist are close at hand. The whole region is surpassingly beautiful and historically one of the most interesting spots in the world. Occasional cruises on the steam yacht or excursions into the country round about give the investigator a chance to combine his collecting work with the most pleasurable of outings. Of the uniform courtesy and liberality of the director, Professor Dohrn, and his assistants, Professors Paul Meyer and Hugo Eisig, as well as other members of the staff, there is no need here to speak.

The advantages enumerated above are, however, already known to any who may happen to have read the reports of the zoologists on their stay there. It is more particularly to another side of the institution, which has not, I am sure, received the attention it deserves from American botanists, that I wish to allude.

Although known officially as the Zoological Station of Naples, the director has from the first recognized the importance of a knowledge of the flora of the Gulf; as many as three volumes of the magnificent *Fauna und Flora des Golfs von Neapel* relate to algæ, and in the *Mittheilungen aus der Zoologischen Station zu Neapel* there are a number of valuable papers on marine plants by Schmitz, Berthold, Falkenberg, and others.

Of still more importance is the fact that in the recently erected west wing of the station building there is a suite of laboratories[2] expressly set aside for botanical work. The ground plan of these rooms is given in *fig. 2*.

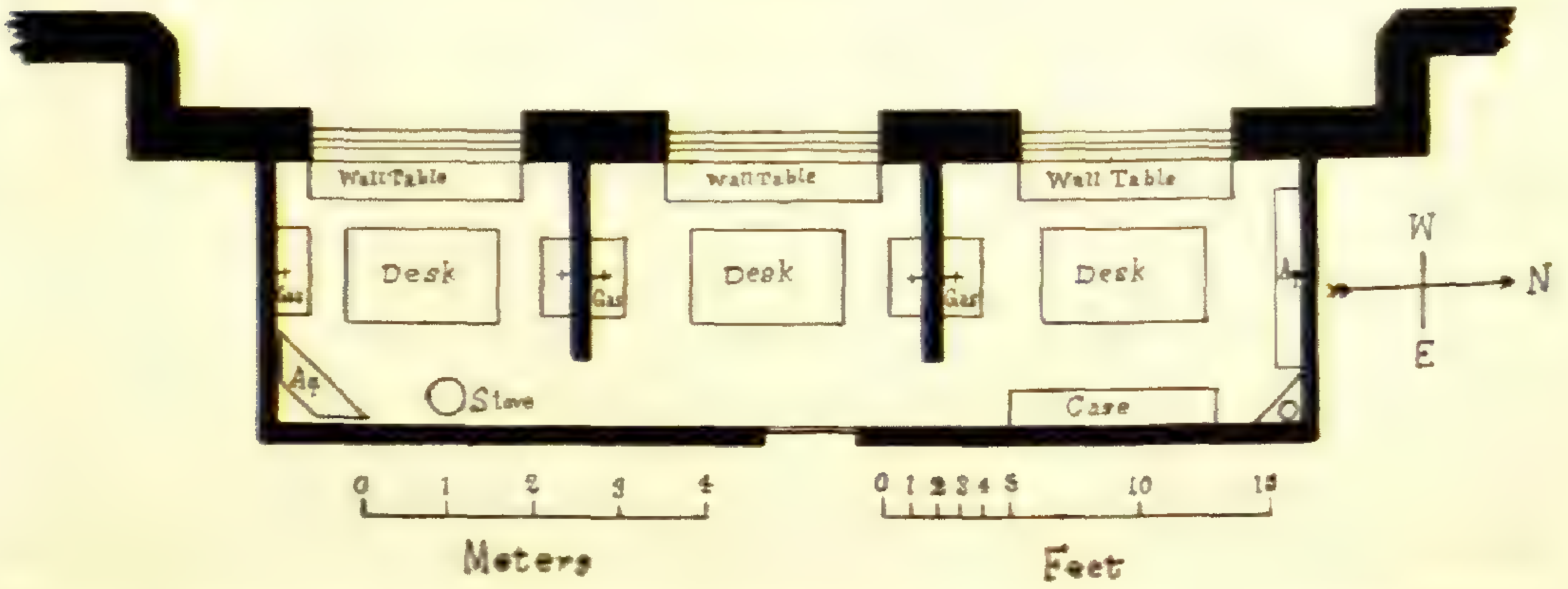

FIG. 2. Ground plan of the botanical laboratories of the Naples Zoological Station.

Hansen[3] has already described the rooms briefly and enumerated the fairly good set of physiological apparatus belonging to them, so I need only state that inasmuch as through the liberality of the American Society of Naturalists two good microtomes are furnished for the use of the incumbents of American tables, and as the station furnishes small but extremely convenient paraffin ovens, cytological and morphological research is as well provided for as is physiological.

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[2] They are behind the three large windows shown in *fig. 1*, and are to be seen also in *Plate XXVII*.

[3] HANSEN, A.: Bericht über die neuen botanischen Arbeitsräume in der zoologischen Station zu Neapel, Bot. Zeit. **50**: 279-285. 29 Ap. 1892. Reprinted with a few changes in Mittheilungen aus d. Zool. Stat. zu Neap. **10**: 654-658. 1 Ap. 1893.

The library, although mainly zoological, has many sets of periodicals containing botanical articles, and possesses in addition about three hundred and fifty volumes exclusively on botany, many of them being very costly illustrated works on marine algæ, and also over seventy-five volumes of botanical reprints and author's copies containing on an average about ten articles each.

There is a very full alcoholic collection of the marine algæ prepared by Berthold and a fairly good local herbarium, which in connection with Berthold's valuable list and sketch of the geographical distribution[4] render it easy, even for beginners in the study of marine flora, to become acquainted with the common forms and to obtain any desired species. The importance of such facilities for those making only a short stay is obvious.

So far, although about thirty-five botanists have worked at the station, many of them at several different times, only three Americans are among the number, namely Dr. H. L. Russell, who worked on bacterial flora of the gulf[5]; Mr. D. G. Fairchild, who studied karyokinesis in Valonia[6]; and the writer, who worked on the cytology of the Sphacelariaceæ.[7] Among other European botanists who have visited the station might be mentioned Goebel, Solms-Laubach, Schmitz, Berthold, Falkenberg, Meyer, Hansen, Fischer, Ambronn, Noll, Went, Valiante, Reinke, Klebs, Famintzin, Golenkin, Klemm, Oltmanns, Benecke.

It should be stated that a table costs five hundred dollars a year, and that at present there are but two supported in this country, one by the Smithsonian Institution and the other by Columbia University. If the splendid facilities for algological work were more generally known I believe that American botanists could easily use at least one table, this too even if, as we all hope, the plans now proposed looking toward the establishment of a tropical botanical station in America can be carried out, for probably there will always be Americans either studying or traveling in Europe to whom the opportunity of spending even a few months at Naples would be very welcome, especially since there are many interesting forms growing there which do not occur in the waters of the New World.—WALTER T. SWINGLE, *Washington, D. C.*

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[4] Berthold, G.: Ueber die Vertheilung der Algen im Golf von Neapel nebst einem Verzeichniss der bisher daselbst beobachteten Arten: Mittheilungen aus d. Zool. Stat. zu Neap. **3**: 393-536. Tab. 1–3. 1882.

[5] Russell, H. L.: Bot. Gaz. **17**: 312-321. Oct. 1892.

[6] Fairchild, D. G.: Berichte d. deut. bot. Ges. **12**: 331-338. *pl. 21.* 1894.

[7] Swingle, W. T.: Jahrbücher f. wiss. Bot. *ined.*

EXPLANATION OF PLATE XXVII.

A view of Naples and Vesuvius, looking east from the summit of the Vomero, an encircling range of hills several hundred feet high. In the midst of the park which extends along the shore may be seen the buildings of the Zoological Station.

BOTRYCHIUM TERNATUM SWARTZ, VAR. LUNARIOIDES (MICHX.) MILDE.[1]

(OSMUNDA BITERNATA Lamarck; B. BITERNATUM Underwood.)

I OFFER the following criticism for two reasons; first, because I cannot agree with Dr. Underwood in his attempt to reinstate Lamarck's species on characters so unreliable as those which he brings forward in his article on the "Rarer Ferns in Alabama;"[2] and second, because I consider it an error to credit Professor Eaton with Milde's combination, as he had nothing whatever to do with it. Again, Dr. Underwood is in error in saying that Professor Eaton "overlooked its very distinct leaf and bud characters"; on the contrary those characters were very carefully considered by Professor Eaton at the time he elaborated the species for his *Ferns of North America*. It was my privilege to be permitted to assist Professor Eaton on that portion of his work, and it was through my finding the Georgia specimen of true *lunarioides* in the Gray Herbarium that he was led to change his original treatment of the species. From this it will be seen that the character of the "leaf and bud" were well known to Professor Eaton and had received proper consideration.

But let us take up, one by one, all of the characters brought forward by Dr. Underwood, and see to what real importance they are entitled.

First, as to the character of the bud. He correctly states that "*B. ternatum* is characterized by its hairy bud," but when he adds "while the bud of *B. biternatum* is smooth," the statement requires some qualification, for in all of the specimens of *lunarioides* in my own private

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[1] Read before the New England Botanical Club, April 2, 1897.

[2] BOT. GAZ. **22**: 407. 1896.

NAPLES and the ZOÖLOGICAL STATION.

collection, and in those in the Davenport Herbarium (Mass. Hort. Soc.), the bud is pilose, and this was true also of the duplicates which I distributed some years ago. Of what value then is an occasional smooth bud except to show that here, as elsewhere, mere pubescence is a variable and unreliable character of no specific importance whatever? The fact is that a similar difference of degree exists in the vestiture of the buds of *B. ternatum* and its var. *lunarioides* as that which exists between the buds of *B. Virginianum* and its var. *gracile*, and we might with equal force contend for the reestablishment of Pursh's species on this ground. In large forms of *B. Virginianum* the bud is usually very shaggy, while in the small forms it is apt to be scantily clothed, and sometimes quite smooth. A similar variation may be found in the buds of *B. ternatum* and its many forms, some being very shaggy, others less so, or only sparingly clothed, or even, as in my specimens from Sweden, nearly smooth. This, it seems to me, effectually disposes of any argument based on the mere presence or absence of pubescence on the bud.

Second, as to "its very distinct leaf." New England botanists who have collected *ternatum* in any quantity know very well that the different varieties merge into one another by almost imperceptible gradations through a great variety of forms, nearly all of which may be found in a series of specimens of the var. *dissectum* alone, thus showing that the mere cutting of the lamina and its consequent differently shaped segments has no specific importance whatever as a basis for separation. Even in individual plants, where the frond of a previous year's growth remains attached, marked differences in the form of the divisions may be found, and I have three fronds taken from one plant in different years that might be taken for different plants by any one not knowing their origin. There are also marked differences in the ultimate segments of individual plants of *lunarioides* itself. I doubt if anyone has seen, or has had pass through his hands, a greater number of these plants, or from a wider range than I have during the past twenty years, and I greatly prefer the comprehensive treatment which Milde gave to this species to any treatment that would break it up into as many species as there are forms. I recognize certain centers of variation, to one or the other of which the different forms can be referred, but it is not possible to separate them into distinct species, as Prantl has attempted to do, without incurring the risk of endless confusion.

Third, as to the relative position of the sterile and fertile divisions of the frond. An examination of a large suite of specimens of *ternatum* and its forms, from a range extending throughout New England, Canada, Alaska, Washington, California, and Mexico, as well as Georgia, South Carolina, Florida, Virginia, and the Middle States, shows that the length of the stalk of the sterile division of the frond is no less variable than are the other characters mentioned, and varies all the way from one-half an inch to six or eight inches or more. In plants from Alaska and Washington, the stalk is generally very short, sometimes not over three-eighths of an inch long, while in a specimen of true *lunarioides* from Florida (*Chapman*) in the Gray Herbarium the stalk is three-fourths of an inch long, and it is more than probable that if we could get as large a number of specimens of *lunarioides* as we do of the other forms we should find an equal degree of variation in the length of the stalk. Dr. Milde's tables of measurements for the different forms of this species show how extremely variable and unreliable this character is.

Fourth, as to its habitat, concerning which little need be said. It is not an uncommon thing to find typical *ternatum* growing in dry soil on high ground as well as in low moist woodlands and swamps. Only last August (1896) I found a fine plant of it growing on a very shallow grassy knoll on top of a granite ledge!

Fifth, as to the spores, the most important of all characters in the botrychiums. Here, as elsewhere, I fail to find any differences to justify specific recognition. An examination of the spores from my Alabama and European specimens shows less difference between the spores of these two forms from such widely separated regions than there is between the spores of the individual plants themselves. In fact they are identical in shape and marking. Neither can I detect any marked distinction between the spores of plants from New England, Canada, Alaska, Washington, California, and Mexico. On the contrary, in all of the forms of *ternatum* which I have examined, the spores of individual plants vary in shape, some being reniform, some pyriform, others oval or egg-shaped, and some even with irregular curved outlines, but the markings appear uniformly the same in all. My examinations have been made with a Leitz $\frac{1}{12}$ immersion objective, and the result shows conclusively that absolutely one type of spore runs through all forms of *ternatum*.

Sixth, concerning the time of perfecting spores, unfortunately, the evidence is incomplete, as we have no knowledge of the fruiting time of *lunarioides* in its more northern latitude. There are, however, some data bearing on the question that lead me to believe that the early fruiting of Alabama plants may be explained naturally without resorting to specific recognition. Milde credits *lunarioides* to Lake Superior (*Macoun*) and Montreal (*Watt*) in Canada, and I cannot believe it possible for him to have been mistaken in any specimens coming under his personal observation. Dr. Watt's specimens I have not seen, but I do not find any true *lunarioides* among the plants which Professor Macoun has very kindly sent to me for examination. His specimens are nearly all identical with the European *rutaceum*, but I am of the opinion that he must have sent *lunarioides* to Milde at some time, or the latter would not have vouched for it. It is not improbable, therefore, that if we had more reliable data it would be found that *lunarioides* in a more northern latitude would mature spores well on into June or July. One thing is certain, however, and that is that the fruiting time of *ternatum* and its forms, throughout its northern latitudes, ranges all the way from June to October, and it is not surprising that in tropical or semitropical climates its range should begin earlier and last longer. It is certain also that a difference of time exists even in the same latitudes between different and even the same forms according to the situations in which they grow. Thus, on Mt. Desert, according to Mr. Rand, normal *ternatum* growing on mountain tops perfects spores in July, while in the woodland swamps at the base of the same mountains it does not mature spores until late in September. In 1879 Dr. Charles Mohr very kindly sent to me a generous supply of *lunarioides*, at the same time calling my attention to its early fruiting, his specimens being collected in March, and the matter was fully considered by Professor Eaton and myself, with the conclusion that this was not in itself of more than varietal importance, and that Milde's disposition of the plant was correct. Nearly all of the specimens which I received from Dr. Mohr had a frond of an earlier growth remaining, and the weather beaten fertile panicle of the older frond had discharged all of its spores, while the panicles on the fresh fronds were only partially developed and the sporangia were immature, and now look as if they would not have been ready to discharge spores for some time longer, perhaps not until well into April; certainly not very remarkable for a southern species that in the north sometimes matures spores in June! On this point Dr. Mohr writes me that the Alabama season extends from January to the middle of April.

But even conceding the importance claimed for this habit of early fruiting, it is still only one point of six left open for consideration, and we may sum up all the characters of *lunarioides* that we have been reviewing as follows:

1. *The bud:* Commonly pubescent, of varying degrees, only rarely smooth; character not of specific value.

2. *The lamina:* Its cutting and shape of the segments; character wholly unreliable, or of varietal importance only.

3. *Relative position of the sterile and fertile divisions:* Sterile division nearly sessile, or short-stalked; scarcely of more than varietal significance.

4. *Habitat:* Character variable and unimportant.

5. *Spores:* Shapes and markings as in the other forms (including type); no specific differences.

6. *Fruiting time:* Evidence incomplete and inconclusive, and doubtfully of more than varietal significance at the most.

My conclusion, therefore, is that Lamarck's *Osmunda biternata* had best remain where Milde placed it, under *B. ternatum* as a good variety.

But here arises another question which it may be well to consider briefly. There is a tendency on the part of some of our later authorities to give to well marked varieties specific recognition, on the ground that it facilitates scientific investigation; and since, at the best, species are merely the arbitrary definitions devised by man for the convenience of study, there would be no serious objection to this if it were not for the numerous intermediate forms that constantly confront us and demand recognition. It is all very well to say that such forms may be disregarded for purposes of classification, but we cannot dispose of them in that way. They are an essential part of Nature's great scheme of evolution, and just as much entitled to recognition as more definite forms. I have known collectors who were in the habit of throwing to one side all puzzling forms that could not be placed readily, so as not to disturb the arrangement of species in their collections, but no close student of nature would be content with such practices. Nature shows little sympathy for our conceptions of species; she deals with large groups, orders, races, and the nearer we approach to her methods the more accurate will our knowledge of her great works become. It is for this reason, therefore, that I prefer that broader recognition of the limitations of a species which provides for all intergrading forms and their variations.

A list of the material used in my examinations may be of interest, as showing the extensive range and cosmopolitan character of this species.

1. Specimens, including all forms, from various parts of New England, from my own collections and those of John Robinson, Walter Deane, Mr. Pringle, and others; beside which I have had access at various times to the fine collections of Professor Eaton, Mr. Faxon, and the especially valuable collection (now in possession of the Appalachian Mountain Club) of the late Mr. E. H. Hitchings; to say nothing of the numerous specimens which I have identified, from time to time, for various collectors and correspondents.

2. Specimens from New York and the Middle States, from the collections of Mrs. Barnes, Rust, Myers, Gifford, and other members of the Syracuse Botanical Club; also collections of E. S. Miller (Long Island), J. H. Redfield (Pennsylvania), Dr. Schneck (Illinois), and others. One of Mrs. Barnes' North Woods plants is remarkable for the small, rounded, almost lunate segments (as in Alabama plants), and the very nearly sessile sterile divisions, the stalk of which is shorter than in Chapman's Florida specimen. Between this and her larger plants, that approximate Californian *australe*, there is every conceivable variation.

3. Specimens from Canada: Prince Edwards Island, north shore of Lake Superior, Northwest Territory and British Columbia, from the collections of Professor Macoun.

4. Specimens from Alaska (*Turner*), Washington (*Suksdorf*), California (*Miller*), and Mexico (*Pringle*).

5. Specimens of *lunarioides* from Georgia (original specimen figured in Eaton's *Ferns of North America*), in Gray Herb.: Florida (*Chapman*, in Gray Herb.); South Carolina, in Herb. Mass. Hort. Soc., donated by Redfield; Alabama, in Herb. Mass. Hort. Soc. and my private collection, from Dr. Mohr. In all of these specimens the bud is pilose.

6. Specimens from New Zealand, in Gray Herb.; Japan (*Oldham*, and a specimen collected by Ångström), in Gray Herb.; also specimens from Sweden in my own collection.—GEORGE E. DAVENPORT, *Medford, Mass.*

SEED CRESTS AND MYRMECOPHILOUS DISSEMINATION IN CERTAIN PLANTS.

A NUMBER of common plants have seeds with whitish fleshy appendages, varying in form and in the extent of attachment to the seed, but at most hardly forming more than a ridge on one side.

In those plants in which dissemination is effected by mammals or birds which swallow the fruit, the fleshy coat completely covers the seed, at least in the ordinary cases, and we would hardly expect these creatures to be attracted by appendages of the limited size of ordinary seed crests. On the other hand, there seems to be no improbability of their being attractive to ants, and they form a very convenient handle by which the ants may seize and carry away the seeds.

A long time ago I noticed that a follicle of *Sanguinaria Canadensis* had dropped its seeds in a cluster upon the ground. Returning to the spot a short time after I was surprised to find that all of the seeds were gone except one in the clutches of an ant which had already dragged it a few feet away. This case was reported verbally to Professor Trelease and was mentioned by him in a paper on myrmecophilism.[1] Since that time I have frequently exposed seeds of Sanguinaria in situations frequented by ants and have observed that these insects invariably seize the seeds and carry them away. On another occasion the contents of several fruits of *Sanguinaria Canadensis*, *Uvularia grandiflora*, and *Trillium recurvatum* were placed in a run frequented by *Formica fusca*, and it was observed that all of the seeds were carried away in about an hour.

The supposition that the plants depend upon the crests for dissemination is strengthened if it can be shown that they have no other means of seed dispersal. In Sanguinaria the follicles remain erect or fall over upon the ground. In either case the seeds are turned out upon the ground without being scattered. In *Erythronium albidum*, which has similarly crested seeds, the capsule bends the scape down so that, when it opens, the seeds roll out.

At first the case of *Uvularia grandiflora* seemed opposed to the supposition, for I was aware of the fact that, while the flowers were pendulous, the position of the capsules was different. This suggested the familiar case in which the flowers are pendulous, but the seeds are finally held in an upright basket where they are retained until a jostling of the plant is likely to throw them to a considerable distance. When this Uvularia is in bloom the leaves are flaccid and pendulous. Later, however, when the leaf through which the peduncle passes becomes rigid and horizontal, the stalk changes its position, but only enough to get out of the way of the leaf. At dehiscence the axis of the capsule is directed horizontally, its valves become strongly reflexed, and the seeds fall out upon the ground.— CHARLES ROBERTSON, *Carlinville, Ill.*

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[1] Psyche —: 179. 1889.

EDITORIALS.

New Species

IN CONNECTION with the nomenclature question, which is proving to be one of great difficulty, it may be well to consider the subject of describing new species. It is a fascinating employment, but, like many fascinating things, has its dangers. That plants must be classified and properly named no one will question, and that this work is very far from completion is no less evident. The proper classification of a form, however, is based upon facts very different from those thought adequate when taxonomy was almost the only phase of botany. In those days, the classification was confessedly artificial, the purpose being little more than a convenient cataloguing of forms. In these days, however, classification is based upon genetic relationships as indicated by a careful study of morphology. As a consequence, those courses of instruction which are logical permit no independent taxonomic work except as a sequence of morphological investigation.

The higher groups, perhaps, present the least difficulty in determining the general relationships of a form ; so that the details of its morphology may not be necessary. But even here such a knowledge of the morphology of the group, and of its habits of variation. is essential as can come only from what is called, for convenience, its monographic study. In view of the immense difficulties of synonymy it would seem wise to reduce taxonomic publication within the limits of reasonable certainty.

In the lower forms, however, and especially in the case of those which are polymorphic, such as many parasitic fungi, hasty taxonomic publication becomes almost inexcusable. One can imagine no more hopeless tangle of synonymy and relationship than that presented by the average list of "new species" dealing with such forms, in which the characters are drawn from form and size, without any knowledge of life history and power of variation. If a botanical congress could devise some code for the suppression or restriction of "new species," it would help towards the application of a code for nomenclature.

OPEN LETTERS.

THE TROPICAL LABORATORY COMMISSION.

To the Editors of the Botanical Gazette:—Dr. J. E. Humphrey, accompanied by a number of advanced students in zoology from Johns Hopkins University, will carry on some investigations in the vicinity of Port Antonio, Jamaica, during the ensuing season, and he has kindly agreed to cooperate with the commission in the examination of that island. His previous experience in Jamaica will enable him to render the commission important and valuable aid.

In the arrangement of plans for the work of the commission, provision will be made for a repetition of a portion of the tour of investigation during the coming winter, in order to appreciate more fully the climatic possibilities of the more promising localities. This will, of course, slightly delay the final selection of a site, but not the organization of the laboratory.

The following quotation from the *Journal of Botany* for March will serve to illustrate the attitude of the British botanists in the matter:

"A botanical laboratory in the western tropics has long been greatly needed, and we have much pleasure in announcing that the establishment of such an institution is completely assured. . . . . It is believed that cordial cooperation on the part of botanists of this country would be welcomed. In order to secure this cooperation we venture to recommend one of the Lesser Antilles as the site. These islands are only a fortnight from London, and their botanical attractions for future work are great. . . . . A site in Mexico, for example, though much to be recommended on other grounds, would be a hindrance to cooperation on the part of botanists in this country on account of the length of the journey. We heartily congratulate American botanists on this manifestation of their enterprise, and wish it the success it undoubtedly deserves."—D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

The abnormal formation of resin ducts.[1]

Dr. Alexander P. Anderson has distributed separates of his thesis presented to the faculty of the University of Munich for the degree of doctor of philosophy. The paper contains interesting matter for botanists, pharmacists, and foresters. A careful perusal of it however, leaves the impression that a large number of more or less interesting facts are here brought together, but without proper assimilation. This may be unavoidable because so little is known of the subject, too little to permit at this time any generalizations; for before the appearance of this paper little had been published upon the matter, the references to it being mostly incidental.

Resin ducts occur normally in the wood of spruces, pines, and larches, and are normally wanting in the wood of balsams, hemlocks, and cypresses. Wood parenchyma (simple resin receptacles, Göpp), according to Krause is present in the wood of all species of Abies. Hartig found a marked irregularity in the number and distribution of resin ducts in certain conifers that had been attacked by *Agaricus melleus*. He also found that in spruces in which so-called double rings were formed on account of late frosts, there is a striking irregularity in the formation of resin ducts in such rings. In 1892 J. Hortman made some comparative anatomical investigations on the shoots from a "witch broom" on *Abies pectinata* and the normal shoots of the same species, in which he found that in the abnormal formation of cortex there is great irregularity in the structure and in the size, as well as a considerable increase in the number of resin receptacles. E. Mer found an abnormal formation of resin ducts in shoots of Abies sp.? as a result of the attacks of *Phoma abietina*.

We must assume that abnormal resin receptacles are present only when the plant is in part or entirely pathologically influenced. If for example resin reservoirs be found in the wood of *Abies pectinata*, they are a sure indication of some pathological condition existing in the plant. Further, with our present knowledge we must assume that resin is strictly an excretion, being of no further use in the metabolism of the plant.

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[1] ANDERSON, ALEXANDER P.—Über abnorme Bildung von Harzbehältern und andere auftretende anatomische Veränderungen im Holze erkrankter Coniferen. Inaug. Diss. Sonderabdruck aus der Forst.-naturw. Zeitsch., 1896. 8vo. pp. 38, *figs. 7.*

Three classes of pathogenic material were used in these investigations: (1) frosted conifers; (2) witch brooms on different species of Abies produced by the growth of *Æcidium elatinum*; and (3) tissues of conifers that had been infected with *Agaricus melleus*, *Phoma abietina*, or *Pestalozzia Hartigii.* In the first case tissues from *Pinus sylvestris*, *Picea excelsa*, and *Chamæcyparis Lawsoniana* were used. When twigs of *P. sylvestris* are frosted but not killed their tissues sometimes lose their power of becoming turgid and the shoots therefore tend to remain in a drooping position. By renewed growth near the tip of the branch the apex again assumes to a greater or less degree an upright position. Where this renewed growth takes place, on the under side of the branch a large amount of the tissue formed is similar to the "red wood" formed on the under side of normal hyponastic branches of *Pinus Strobus* and *Picea excelsa.* In both cases there are fewer resin ducts on the side of the twigs having "red wood" than on the other. "Double rings," or "frost rings," are sometimes formed in the two, three, or four-year-old parts of frosted pine shoots. In such cases there are generally no vertical resin ducts in the inner half of the annual ring. This is true also of *Picea excelsa.* The annual ring, with frost ring, in this species is essentially like that of *Pinus sylvestris* so far as structure, number, and distribution of ducts is concerned. In some instances, where the frost ring is formed late or where two are formed in one season, there may be developed a complete circle of resin ducts in the frost ring itself. Resin ducts are abnormally formed in the bast in twigs of *Chamæcyparis Lawsoniana* as a result of frosting in late spring. The ducts are formed where the cells have been forced apart by the formation of ice masses between them and they have failed to return to their normal position after the melting of the ice.

In the investigations on the "witch brooms" from species of Abies, particularly *A. pectinata* and *A. firma*, tissues of the tumor produced at the original point of infection of the leaf, of the twig and of the buds were employed. The branches of the "broom" on *A. firma* are negatively geotropic, have about twice the diameter of the normal branches and are relatively shorter. The diseased twigs develop very early as do the needles upon them, while the normal ones are much later. The latter are much thicker and about one-half the length of the normal leaves. In *A. firma* the diseased needles do not fall in the autumn, while in *A. pectinata* they do. In both the needles show no transverse heliotropism. The buds are relatively larger than those of normal branches; they have a greater number of scales but these are smaller than in the healthy bud. The resin ducts in the diseased bud scales have the regular form, but they are either abnormally large or abnormally small and have fewer and more irregular epithelial cells than have the normal scales. The mycelium of the fungus penetrates all parts of the tissue except the cavity of the ducts and the epithelial cells. Generally there are fewer stomata and trichomes and a smaller amount of fibro-vascular tissue than in the normal scale. In the rudimentary leaves and summit of the stem there are neither resin-ducts nor mycelium during the winter. Resin ducts develop earlier in the season in the cortex of the twigs of the "broom" than in normal twigs, and they are always present in greater numbers in the former than in the latter.

In the cortex of the "witch broom" tumor it occasionally happens that the communication by way of resin ducts between the diseased parts above the point of infection and the healthy parts below it is broken. Ducts are never formed in the phloem, while in the wood they are present in every annual ring. The diameter of these ducts and their number are greatest at the middle part of the tumor. From this point toward either end the diameter, number, and number of epithelial cells in each, diminishes. At the lower end all the ducts are pointed and terminate between diseased and normal wood. In the upper extremity all ducts which end with the tumor are pointed. Ducts seem to occur as often in the wood of healthy twigs having their origin above the point of infection as in that of the diseased ones. In the wood of the tumor there is usually, in each annual ring, a circle of ducts and sometimes two such circles.

Tissues of *Picea excelsa*, *Pinus Strobus*, and *Larix Japonica* infected with *Agaricus melleus* show that there is an increase in the number of vertical ducts in the diseased wood ring in all parts of the plant above the point of infection. The greatest increment of wood in the diseased ring is found in the upper part of the plant, from which downward the thickness of the ring decreases. With this decrease in thickness there is a corresponding increase in the number of resin ducts per square unit of section surface. In *Abies pectinata* infected with *Phoma abietina* resin ducts occur only in the healthy wood above the diseased part of the branch. These ducts are similar to those in the wood of the "witch broom" on Abies. Tissues of *Abies pectinata* and *Picea excelsa* infected with *Pestalozzia Hartigii* show in the former the formation of abnormal ducts only in the sound wood above the diseased part of the stem and in the latter the formation of a larger number of ducts in the healthy wood above the diseased part of the stem than is found in normal spruce wood.—L. S. CHENEY.

The sensibility of plants.

PHYSIOLOGISTS are engaged in the effort to bring the phenomena of sensibility of the plant and animal into a system with uniform terminology. One group of writers insist upon the elevation of the forms of sensibility of the plant to the dignity of senses, coordinate with those of the animal. A second group, basing their conclusions upon the reflex nature of the reactions of the plant, see nothing in them beyond highly specialized forms of irritability.

The text of a recent popular address by Dr. Noll is of interest in this connection.[2] The popular superstitions and fanciful theories of the intelligence, spiritual life and sensibility of plants since the time of Empedocles (fifth century B. C.) are brought into review in the light of modern investigation, and following a summary of the results upon which the current theories of irritability are based, the author enters upon a highly metaphorical discussion of the true nature of the sensibility of plants. Defining a sense he says: "The ability to feel the relations of the surrounding world, or objectively expressed, to receive these relations as stimuli, and react by variations in the life processes, is to be designated as sense." Psychologists are not so easily satisfied, however. With such definition as a basis the author proceeds to the statement, "that portions of plants are to be recognized, which not only *can*, but *must* be designated as *sense organs*." To term the pulvinus of Mimosa a specific sense-organ does not attain the advantage of inclusion of similar things under single terms as claimed by the author.

It is to be seen that the greater portion of the paper was not meant to be taken too seriously or literally by the audience to whom it was addressed, for in the concluding paragraphs it is pointed out that the presence of consciousness or of any of the psychic functions of a centrally organized nervous system has not been demonstrated in plants, and therefore that real senses are wanting, since a reflex connection of the motor and sensory zone meets every necessity of existence. Weber's law of the relation of stimulus to reaction, once thought to be a test of the presence of consciousness, has been found to apply to some reactions of plants, but since it is possible to construct a machine which will obey this law, it has lost its significance in this connection.

The author has appended a series of critical notes on the various questions suggested in the lecture. An interesting comparison is made of the greater degree of perfection of the sensibility to gravity in the plant, with the function of the otocyst in lower, and the semi-circular canals of the ear in higher animals. Great importance is attributed to the interprotoplastic threads in the conduction of impulses, though the writer does not seem aware of the fact that the interruptedness of the nervous tissue of animals is universally accepted. In harmony with the work of the reviewer the curvature of tendrils in response to changes in temperature are not regarded as reactions in the same sense as those to contact, etc.

A discussion is given of Czapek's objections to Noll's theory of the irritability of secondary roots, and of Pfeffer's adverse criticisms of certain phases of "heterogene Induktion," but no new facts are adduced. The value of figurative discussions of the nature of the irritability of plants is extremely doubtful. In no part of the subject is it more necessary to keep the feet on

[2] **Das Sinnesleben der Pflanze.** Sonderabdruck a. d. Ber. u. d. Senkenbergische **Naturf. Ges. i. Frankfurt, a M. 1896.** Vortrag gehalten 31 Mai. 1896.

solid ground, and advance should be made from fact to fact only. Popular literature is quite full enough of fanciful conceptions of plants without additions from the laboratory.

The entire paper, however, will be interesting reading to that class of biologists who profess to see in plants a series of degraded forms, which began retrogression on the acquisition of the habit of fixation.—D. T. MACDOUGAL.

MINOR NOTICES.

THE CŒUR D'ALENE mountains of Idaho have long been known as interesting botanical ground. All of northern Idaho presents that combination of conditions which has resulted in an unusual flora. During the summer of 1895 Mr. John B. Leiberg undertook a botanical survey of the Cœur d'Alenes, under the direction of the Division of Botany, of the Department of Agriculture. This survey was the more significant and fruitful as Mr. Leiberg had lived in northern Idaho for about ten years, and was already very familiar with the region. A contribution[3] just published gives us some of the results, dealing with matters both biologic and economic, as follows: topography, drainage, climate, mineral deposits, agricultural capacity, agricultural products, grazing lands, native food plants, utilization of water supply, forest resources, forest zones, forest destruction, burned areas, forest preservation, and a new system of timber protection.—J. M. C.

RECENT BULLETINS from the experiment stations embrace a variety of botanical subjects. E. J. Durand (Cornell no. 125) describes a disease of currant canes observed in New York and New Jersey not before noted in this country. Three fungi were found: *Tubercularia vulgaris, Nectria cinnabarina* and *Pleonectria berolinensis*, of which the first two are the chief or only cause of the disease, and also are undoubtedly forms of one species. Little was accomplished with cultures and inoculations. A. S. Hitchcock (Kans. no. 62), in thirty-four pages and ten plates, gives much information about two species of corn smut (Ustilago). Successful infection experiments were made. A. D. Selby (Ohio no. 73) briefly describes and illustrates a number of fungous diseases of the forcing house and garden. R. H. Price (Texas no. 39) gives a general account of the peach, including notes of botanical interest on diseases and on the five classes. A popular account of bacteria and their study is presented by C. E. Marshall (Mich. no. 139) in thirty-seven pages. Three troublesome weeds: *Hieracium aurantiacum, Daucus Carota* and *Solanum rostratum*, are briefly described by F. L. Harvey (Me. no. 32). Geo. Vestal gives a popular account of the care and handling of seeds (N.

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[3] LEIBERG, JOHN B.—General report on a botanical survey of the Cœur d'Alene mountains in Idaho during the summer of 1895. Contrib. Nat. Herb. **5**: 1–85. 1897.

M. no. 20). Attention is called to the value of mushrooms and puffballs for food by L. M. Underwood (Ala. no. 73) in ten pages. Specific description is accorded *Agaricus campestris, Amanita Cæsarea*, said to be common in Alabama, and its poisonous relative *A. muscaria*. A chemical study of the Irish potato by T. L. Watson (Va. nos. 55 and 56) contains some facts of interest to vegetable physiologists.—J. C. A.

NOTES FOR STUDENTS.

MR. THEO. HOLM, in the continuation of his morphological and anatomical studies in the Cyperaceæ, has recently investigated *Carex Fraseri*,[4] a very rare and local sedge with an appearance so peculiar as to distinguish it easily from other species of Carex. His results still further emphasize this distinctness. "The monopodial ramifications of its rhizome, with its single assimilating leaf destitute of sheath, ligule, epidermal expansions and bulliform cells, in connection with its flat and hollow stem, besides the uninterrupted pericambium of the root, constitute a structure that seems almost unique in the family of the Cyperaceæ."—J. M. C.

AN INTERESTING CONTRIBUTION to the subject of rhythm in plants is afforded by L. Jost's recent work on Mimosa.[5] This plant is one of the few known examples in which etiolated leaves are irritable, and which exhibit periodic movements. In the experimental work etiolated leaves were obtained by enclosing the tip of a branch in a dark chamber. The periodic movements of the enclosed etiolated leaves were not induced by impulses from the free leaves, since artificial alterations in the periods of illumination and darkness of the latter produced no variations in the movements of the enclosed organs. The periodic movements of green as well as etiolated leaves of Mimosa are due largely to variations in temperature. Rise in temperature causes the leaves to assume the night position, and a fall in temperature the day position; exactly the reverse of the relations of flowers to temperature. This fact is remarkable in view of the fact that leaves and flowers react alike to changes in the intensity of light.—D. T. MACDOUGAL.

MR. T. CHALKLEY PALMER has succeeded in demonstrating, by a very simple device, that diatoms absorb carbon dioxide and exhale oxygen under the influence of light. While these indications of photosyntax were not needed to prove that diatoms are plants, the simplicity of the device makes the demonstration an easy one to employ in illustrative work. Advantage is taken of the fact that an ordinary aqueous solution of haematoxylin loses its

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[4] Am. Jour. Sci. IV. **3**: 121–128. *pl. 4*. 1897.

[5] Ueber die periodischen Bewegungen der Blätter von Mimosa pudica in dunkeln Raume. Bot. Zeit. **55**: 1 Abth. Hft. VI, Feb. 16, 1897.

"normal rosy or slightly bluish-red tint," when exposed to carbon dioxide, and becomes "yellow with a tinge of brown;" and "in the presence of nascent oxygen the light red hue deepens momentarily and ends by becoming a very deep blood red." In a properly guarded test tube a solution of haematoxylin is placed which has been acidified with carbon dioxide. Into the brownish-yellow liquid living diatoms are placed and exposed to bright light. Gas arises, and within fifteen minutes the color has become quite red, continuing to deepen in color until it is blood red. By using two tubes filled with normal reddish solution of haematoxylin, and placing a living snail in one and diatoms in the other, the former pales rapidly under the influence of the carbon dioxide from the snail, while the latter rapidly darkens and reddens. In all cases, of course, other tubes containing the solution are used as checks.—J. M. C.

DR. ANTON HANSGIRG[6] has recently investigated the ability of plolen to resist water, and the relation between this power and the protection against rain and dew. Since many plants whose pollen grains and sporophylls are fully protected against rain and dew have very resistant pollen, and, on the other hand, plants with exposed sporophylls often have pollen very sensitive to moisture, he considers Lidforss' parallelism between protection against rain and the resistance power as questionable. Although the cohering pollen of many plants needs protection against too early wetting, there are many entomophilous plants whose pollen can withstand wetting without injury. In different families and genera there are many intermediate forms between these and those with pollen very sensitive to moisture. The author gives a long list of plants whose pollen germinates well in pure water, but whose sporophylls are not protected against wetting. Another list includes those whose sporophylls are protected against wetting, but whose pollen germinates thoroughly in pure water. Plants whose pollen germinates poorly or not at all in pure water will be noted later, the present paper being a preliminary statement.—C. J. C.

J. M. JANSE has published recently an account of his researches upon root endophytes.[7] He examined forty-four dicotyledons, fourteen monocotyledons, five gymnosperms, and six cryptogams. In these cases the endophyte failed to appear in but one dicotyledon, three monocotyledons, and two cryptogams. The plants studied were taken almost entirely from natural conditions, and many specimens of each type were used in order to avoid exceptional cases. The superficial roots are inhabited more often than the deeper ones. A filament of the fungus forces its way through the epidermis, and usually without branching passes directly through the outer layers of cells. Then the hypha branches rapidly and invades the tissue longitudinally. In this region of branching many "vesicles" are formed. It is thought that these "vesicles" may be cysts which germinate when they are freed by the disintegration of the root. Usually the fungus penetrates deeper than the region of "vesicles," and forms "sporangioles." These are not reproductive bodies, but disintegrate soon after formation. They are formed within cells only, while the "vesicles" may be either in cells or intercellular spaces. The fungus never penetrates the endodermis, and usually stops with one or two layers of cells separating them. It never enters cells which contain no nutritive substances, and evades scrupulously those which contain such substances as tannin and resin. It seldom enters cells containing chlorophyll; but in a few cases where aerial root cells contained chlorophyll on one side, the endophyte was found to occupy the other side of the same cells. The fungus nourishes itself with the starch grains of the infested cells and those adjacent to them. This loss of starch marks the only possible detrimental effect in the host cells.

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[6] Zur Biologie des Pollens. Oesterreichische Bot. Zeitschrift **47**: 48–52. 1896.

[7] Ann. Jard. Bot. Buit. **14**: 53–202. 1896.

The systematic affinities of the endophyte are absolutely unknown, although several authors have described it or some similar form. Jansen claims that none of the forms so described can be the one which he presents. There is variation in the structure of this endophyte in different hosts, but the "guest" seems to maintain its identity sufficiently throughout its various habitations. The slight morphological differences do not necessarily indicate physiological differences.

The author thinks the association of the endophyte with its host one of mutualism ("commensaux"). He likens it to such conditions as exist between Rhizobium and the root tubercles of the Leguminosæ, and *Saccharomyces Kefyr* and *Bacillus Causasicus*. The endophyte evades free oxygen, as is shown by its aversion to chlorophyll cells. The host plant gives it a hiding place, and it is also furnished with food in the form of starch. The nuclei of the host cells in which the "sporangioles" are breaking down become very large and divide rapidly, giving evidence of being well nourished by the nutritive matter of the "sporangioles." The host cells use a large part of the nitrogen compounds of the "guest." Experiments upon coffee plants show that they grow best when their roots are inhabited by the endophyte.—O. W. C.

CENTROSOME LITERATURE has received a notable addition in the recent contribution of R. Lauterborn[2] upon diatoms. Various species of Surirella and Pinnularia form very favorable objects for the study of centrosomes, since these bodies can readily be seen in Surirella even in the living condi-

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[2] Untersuchungen über Bau, Kernteilung und Bewegung der Diatomeen: Aus dem zoologischen Institut der Universität Heidelberg. Leipzig. 1896.

tion. The author's investigations on this point are exceedingly interesting. There is one centrosome which lies in a depression beside the resting nucleus. The centrosome appears "naked" in the living condition, no attraction sphere being seen around it. The author agrees with Häcker that the attraction sphere is an artificial structure produced by plasmolytic contraction of the centrosome. While the nucleus is in the resting stage there are no radiations around the centrosome; but when nuclear division begins the centrosome passes out of the depression and becomes surrounded by exceedingly well defined radiations, which appear as definite in the living state as in fixed preparations or more so. There is a close relation between the centrosome and nucleus, which becomes apparent when the nucleus is forcibly removed from the cell. In this case the centrosome remains attached to the nucleus even if all the cytoplasm from both has been torn loose. The fact that the centrosomes, as in Surirella, can be seen plainly in living cells is a strong argument against the temporary organ hypothesis. The centrosome is a kinetic center from which, at the beginning of nuclear division, activities proceed out upon the nucleus and cytoplasm, which appear morphologically as radiations around the centrosome. When the radiations appear a new body arises in close proximity to the centrosome, which is the beginning (*Anlage*) of the central spindle. This body appears to come from the centrosome by division or budding, although the process was not observed. The central spindle body soon increases in size and begins to pass through a series of peculiar forms. It elongates and becomes sheaf shaped, and when the nuclear membrane has disappeared, it enters into the nucleus, and the chromatin segments arrange themselves about its equator and are then carried to the poles. The author has very carefully observed that the central spindle body is not to be confounded with a nucleolus. Before the central spindle enters into the nucleus the centrosome begins to vanish. During the formation of the daughter nuclei a centrosome appears at each end of the central spindle, and when the nucleus is about completed a centrosome lies in the nuclear depression at the central point of the cytoplasmic radiations. At this stage nothing more is to be seen of the constricted ends of the spindle. Their substance is very likely withdrawn into the centrosomes. The origin of the two centrosomes at the poles was not definitely determined. Either secondary centrosomes are formed at the two poles of the central spindle whereby the original centrosome goes to pieces, or, since the original centrosome is always near at hand, the two dark hemispherical bodies which appear on both sides of the central spindle may be formed by division of the original centrosome, and these two bodies later become differentiated into new centrosomes, one for each daughter nucleus. The whole nuclear and cell division in *Surirella calcarata* was completed in from five to five and one-half hours.—J. H. S.

ITEMS OF taxonomic interest are as follows: In their continuation of Welwitsch's African freshwater algæ, Messrs. W. West and G. S. West describe three new genera;[9] *Psephotaxus* (Ulotrichaceæ), *Temnogametum* (type of a new family of Conjugatæ, in which conjugation occurs only between specially abstricted cells); and *Pyxispora* (Zygnemaceæ). Bulletin 4 of the Division of Agrostology contains a revision of the genus Ixophorus by F. Lamson-Scribner; a list of the grasses collected by Dr. Palmer near Acapulco, Mexico, in 1894–5, among which is a new genus *Fourniera* (Zoysieæ), by the same author; some Mexican grasses collected by E. W. Nelson in 1894–5, by F. Lamson-Scribner and Jared G. Smith; some American Panicums in the Herbarium Berolinense and in the herbarium of Willdenow, by Theo. Holm; native and introduced species of Hordeum and Agropyron, with keys, by F. Lamson-Scribner and Jared G. Smith; and miscellaneous notes and descriptions of new species, among which *Chætochloa* Scribner is proposed as a new generic name for Setaria, which is untenable for several reasons, and neither Chamæraphis nor Ixophorus is available as both are well-defined genera and abundantly distinct. Bulletin 6 of the Division of Agrostology gives a full account of the grasses and forage plants of the Dakotas, by Thomas A. Williams. Mr. P. A. Rydberg, in continuation of his studies of Potentilla,[10] describes four new species. Miss Anna Mary Vail has published notes on Parosela[11] (Dalea), which include descriptions of three new species, besides the transfer of specific names. Dr. Charles Mohr has published notes on some undescribed and little known plants of the Alabama flora,[12] among which are new species of Sagittaria and Oldenlandia. Mr. Geo. V. Nash has described[13] new species of Erianthus, Paspalum, Panicum, Agrostis, and Danthonia. A new Prunus from Connecticut, *P. Gravesii*, is described by Mr. John K. Small,[14] and a new Crataegus from Virginia, *C. Vailiæ*, by Dr. N. L. Britton.[15] In the continuation of the account of Welwitsch's African fresh water algæ,[16] among the numerous new forms of Desmidiaceæ, W. West and G. S. West describe a new genus, *Ichthyocercus*. The February number of the *Bull. Torr. Bot. Club*[17] contains descriptions of numerous new fungi, chiefly from Alabama, by L. M. Underwood; a new Lechea from Maine, by E. P. Bicknell; a new violet of the Atlantic coast and a new geranium, by N. L.

[9] Jour Bot. **35**: 33–42. 1897.

[10] Bull. Torr. Bot. Club **24**: 1–13. *pls. 287, 288.* 1897.

[11] Bull. Torr. Bot. Club **24**: 14–18. 1897.

[12] Bull. Torr. Bot. Club **24**: 19–28. *pls. 289–291.* 1897.

[13] Bull. Torr. Bot. Club **24**: 37–44. 1897.

[14] Bull. Torr. Bot. Club **24**: 44. *pl. 292.* 1897.

[15] Bull. Torr. Bot. Club **24**: 53. 1897.

[16] Jour. Bot. **35**: 77–89. 1897.

[17] Bull. Torr. Bot. Club **24**: 81–86, 86–90, 92–93, 93–94. 1897.

Britton; and a new Ribes from Idaho, by A. A. Heller. Mr. F. V. Coville[18] has described a new Collomia from Oregon, and Mr. John B. Leiberg[19] a new Delphinium and a new Sambucus from the northwest coast. G. Hieronymus[20] has begun the publication of the spermatophytes of the Argentine Republic, Uruguay, Paraguay, Brazil, and Bolivia, the first paper including the Vernonieæ and Eupatorieæ. The great display of these tribes to the south may be judged by the fact that over 200 species are presented, almost 100 of which are new. The three great genera are Vernonia, with fifty-six species, twenty-five of which are new; Stevia, with forty-five species, twenty-seven of which are new; and Eupatorium, with seventy-five species, twenty-six of which are new.—J. M. C.

ABOUT THREE YEARS AGO the Hatch Experiment Station published a bulletin upon the effect of the electric current in promoting the growth of plants, which was somewhat adversely commented upon in this Journal.[21] The same station has now issued another bulletin dealing with the subject from another standpoint. The work was done by Asa S. Kinney,[22] under the supervision of Professor George E. Stone, and relates chiefly to acceleration of growth during germination. Very few of the attempts to study the action of electricity upon plant life have made any substantial contribution to our knowledge of the subject. The present paper, however, appears to show that beyond doubt a small alternating current of moderate frequency and fairly high voltage when applied for a short time has a stimulating effect upon growth.

The experiments were in three series. In the first series 200 seeds of a kind, after being soaked in water for twenty-four hours, were divided into lots of twenty-five seeds each, and exposed to the electric current at different voltages for two minutes, with exception of one lot kept for comparison. Seeds of white mustard, red clover, rape and barley were used. The source of the current was four Leclanché cells, acting upon a secondary induction coil through a primary coil and interrupter. The results are shown in the number of seeds germinating at intervals of 24, 48 and 72 hours, and the average length of the radicles at the close. A second trial was carried out in the same manner, but using two Samson no. 1 battery cells, and continuing the treatment five minutes instead of two. A third trial was made in all particulars like the first trial but omitting the barley, and continuing the observations to a fourth interval of ninety-six hours, and measuring both radicle and hypocotyl. For the three trials 2200 seeds were used.

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[18] Proc. Biol. Soc. Wash. **11**: 35–37. 1897.

[19] Proc. Biol. Soc. Wash. **11**: 39–41. 1897.

[20] ENGLER'S Bot. Jahrb. **22**: 672–798. 1897.

[21] **19**: 88. 1894.

[22] Electro-germination. Bull. Hatch Exper. Station, no. 43. 32 pp. Illust. 8vo. Amherst, January 1897.

The resulting data show a convincing uniformity. In all cases there was an increase in the rapidity of germination and elongation of the radicle and hypocotyl in the treated seeds, with a distinct optimum above and below which the treatment was less effective, although never injurious.

In the second series 100 seeds each of white mustard, rape and red clover were used in lots of twenty-five. The treatment was for two minutes. One lot received the current as in the first trial of the previous series using what had been shown to be the optimum voltage. The second lot was treated in the same manner except that the number of interruptions of the primary current was reduced from about 6000 for the two minutes to 10. The third lot received the direct current from the cells; and the fourth lot served for comparison, being untreated. Two trials were made, corresponding to the first and third trials of the previous series, 600 seeds in all being used.

The resulting data show a favorable effect from all three forms of treatment, there being small difference between them in hastening germination, but in growth of radicles and hypocotyls the alternating current of higher frequency giving best results.

The third series is not so fully reported as the others, but was equally satisfactory in results. It consisted in stimulating seedlings at regular intervals for some days, in order to see if beneficial effects would continue to be shown as the plants grew. The current was the same as in the first trial of the first series, and was passed through a funnel or flower pot of moist sand in which the seedlings were grown. By attaching the primary wires to a clock movement the current was set up for about thirty seconds at the beginning of each hour. In one trial seedlings of horse bean (Vicia Faba) were observed for two days, and in another trial seedlings of white lupine (Lupinus albus) were observed for fourteen days. Both trials gave increased growth.

These several experiments and their results are clearly and concisely reported, and in a form that makes the data valuable for study. The report is not accompanied, however, with any discussion of the physiological action of electrical stimuli, or of the philosophy of the mode of treatment adopted. These are very alluring topics, but must be passed over for the time being. J. C. A.

THE EXPERIMENTS whose results are embodied in a late paper were begun on the influence of temperature upon the osmotic processes in living cells in 1892 by Professor Krabbe, but the manuscript was left unfinished at his death, and prepared for publication by Dr. Kolkwitz.[23]

All attempts to prove with living cells, as was done with his artificial cell by Pfeffer, and in theory by von t'Hoff, that the osmotic pressure is proportional to the absolute temperature, were unsuccessful, the turgor being too high at low temperatures. In investigating the influence of temperature on the rapidity of the osmotic movement of water more satisfactory results were obtained. It was found, for instance, that if cylinders of the pith of Sambucus 180.5^{mm} long were placed in a 24 per cent. cane sugar solution at 0 to 1°C., and at 20°C., the contraction in $2^h\ 15^m$ was to 176.5^{mm} in the former, to 147^{mm} in the latter; that is, at 20° more that eight times as much water had been given off as at zero, transverse contraction being neglected. Conversely, when pith was placed in distilled water at 4° and at 26°C., the elongation within 15^m was about four times as great in the latter as in the former. In experiments with roots (*Vicia Faba* and *Phaseolus multiflorus*) the difference was less, the ratio never exceeding 1 to 2.5 during the first five minutes, and decreasing with the duration of the experiment. The ratio of the amount of elongation of plasmolysed roots in distilled water at 4° and 26°C. was about 1 to 3 during the first ten minutes. Poiseuille's formula provides for an average increase in the viscosity of water of 0.034 for each degree C. above zero. Pfeffer's observations at 7.1°, 17.6°, and 32.5°C. suggest an increased rapidity of osmosis through copper-ferrocyanide membranes of 0.045 per degree, or from 1 to 1.9 with 20° increase. His own figures being considerably higher, Krabbe concludes that they must depend on the living nature of the protoplasm. At a low temperature, the condensation of the protoplasm makes it so resistent to the passage of water that if pith cylinders in ice water, whose elongation has ceased, be split, the halves become concave on the inner surface. In a certain sense the condition of the protoplasm here regulates the turgor without being pervious to anything but water.[24] Krabbe believes that at 24°C. the intermicellar openings are already large enough to permit some exosmosis of the cell content into pure water, but no figures are given in proof.

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[23] KRABBE, G: Ueber den Einfluss der Temperatur auf die osmotische Processe lebender Zellen. Jahrb. f. wiss. Botanik **29**: 441.

The increased inner friction of water when cooled, represented by Poiseuille's formula, may claim more or less of a share in the decreased rapidity of osmosis, as it is slightly or decidedly overshadowed by friction against the membrane. But the latter element is always present, and when 50 to 200 membranes obstruct the way it may well suffice to explain the difference of tensions at surface and interior of the pith cylinders. It is no more reasonable to expect different membranes to show like variation in this respect than to assume for all substances a common coefficient of expansion when heated. The resistance to filtration is an unknown[25] function of the diameter of the interstices. The finer these already are, the greater must be the effect of a given further decrease; so we should anticipate for protoplasm, impermeable to many substances, KNO_3 etc., which traverse the copper ferrocyanide membrane a considerably more marked response to changes of temperature than is displayed by the latter. This being so, it is unnecessary to refer the difference to the vitality of the protoplasm.

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[24] Cf. Pfeffer, Zur Kenntniss der Plasmahaut und der Vacuolen, etc. 302 [156].

[25] In capillary tubes of measurable size, the resistance varies with the fourth power of the radius; in the case in question the power is probably higher.

Essentially the same phenomenon described by Krabbe is that of bleeding, decreasing rapidly as it does with falling temperature, and usually ceasing some degrees above zero.

While in the life of the plant the protoplasm must permit the wandering of various food matters from cell to cell, and, therefore, be permeable to them under circumstances which we do not sufficiently understand, it is extremely doubtful if perfectly healthy cells ever permit exosmosis of anything except water when immersed at room temperatures. Determinations of turgor are ordinarily made at such temperatures, and though Krabbe does not carry his point so far, their accuracy would at least be shaken by the possibility of such a process. And as plants live and grow at such temperatures, what is to limit the filtration of the sap from the cells? That this does not occur so as to be appreciable by any test of plasmolysis, or measurement, unless by fine chemical reactions, needs no argument. That it does begin with injury to the protoplasm is a matter of common experience receiving critical attention from De Vries.[26]

Last year the writer had occasion to determine very carefully the turgor of leaves of several mosses, and of the roots of *Vicia Faba* and other phanerogams at temperatures from 0° to 37°C., and while the temperature appreciably affected the time required for plasmolysis, it had not the slightest discernible influence on the ultimate result. These experiments covered a wider range of temperature than Krabbe's. The conditions were different in that practically all the cells were in immediate contact with the plasmolysing solution. And while the results confirm Krabbe's conclusion that the combined resistance of many layers of protoplasm is responsible for the difference of tension in cold water between the axis and periphery of pith cylinders, and for their failure to plasmolyse completely at 0 C., they are unfavorable to the idea of the filtration from the healthy cell of any of its turgor-producing contents. Any such action was a stage of death.

Finally the statement that pith in cold water does not stretch beyond its limit of elasticity holds good according to Kolkwitz[27] only when the time of immersion does not exceed four to six hours.—E. B. COPELAND.

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[26] Bot. Zeit. **42**: 289.

[27] Fünfstück's Beiträge zur wiss. Botanik, 1895.

NEWS.

THE ROYAL ACADEMY of Sciences of Berlin offers a prize of *M* 2000 for a memoir on the origin and characteristics of the varieties of grain during the last twenty years. The manuscript, which may be written in German Latin, French, English or Italian, must be sent to the Bureau of the Academy (Universitätsstrasse 8, Berlin NW., before Dec. 31, 1898, with name of the writer in sealed envelope. The work must be based upon special experiments and observations.

THE HOPI are one of those interesting tribes which remain as relics in the desert and cañon region of the southwest. Compelled to utilize everything organic that is available, in the paucity of animals they have made a surprisingly complete use of their scanty vegetation. Mr. Walton Hough has made a collection of the Hopi plants, which have been named by Dr. J. N. Rose and published, with their native names and uses, in the *American Anthropologist* for February. It is estimated that there are not over 150 indigenous species in the Hopi environment, northeastern Arizona, but Mr. Hough's collection reveals the fact that about 140 of these are used in agriculture and forage, arts, architecture, domestic life, dress and adornment, folk lore, food, medicine, and religion.

THE PROCLAMATION of President Cleveland setting apart thirteen new forest reserves, representing an area of more than twenty one million acres is noteworthy. This increases the total reserve forest land in the West to thirty-nine million acres. We quote from *Garden and Forest* in stating that the new reserves include all the central portion of the Black Hills of South Dakota, the Big Horn mountain range in Wyoming, the Jackson lake country south of the National Park in Wyoming, all the Rocky mountains of northern Montana, a valuable forest region in northern Idaho, the principal part of the Bitter Root mountain region in Montana and Idaho, the Cascade mountains of northern and southern Washington, the Sierra summits of California north of the Yosemite National Park, the San Jacinto mountains in southern California, and the Uintah mountains in northern Utah. The selection of these forest lands was made by the commission appointed by the National Academy of Sciences. Since the proclamation strenuous objections have been made by interested inhabitants, so that it is difficult to tell whether it will become operative throughout all the areas indicated.

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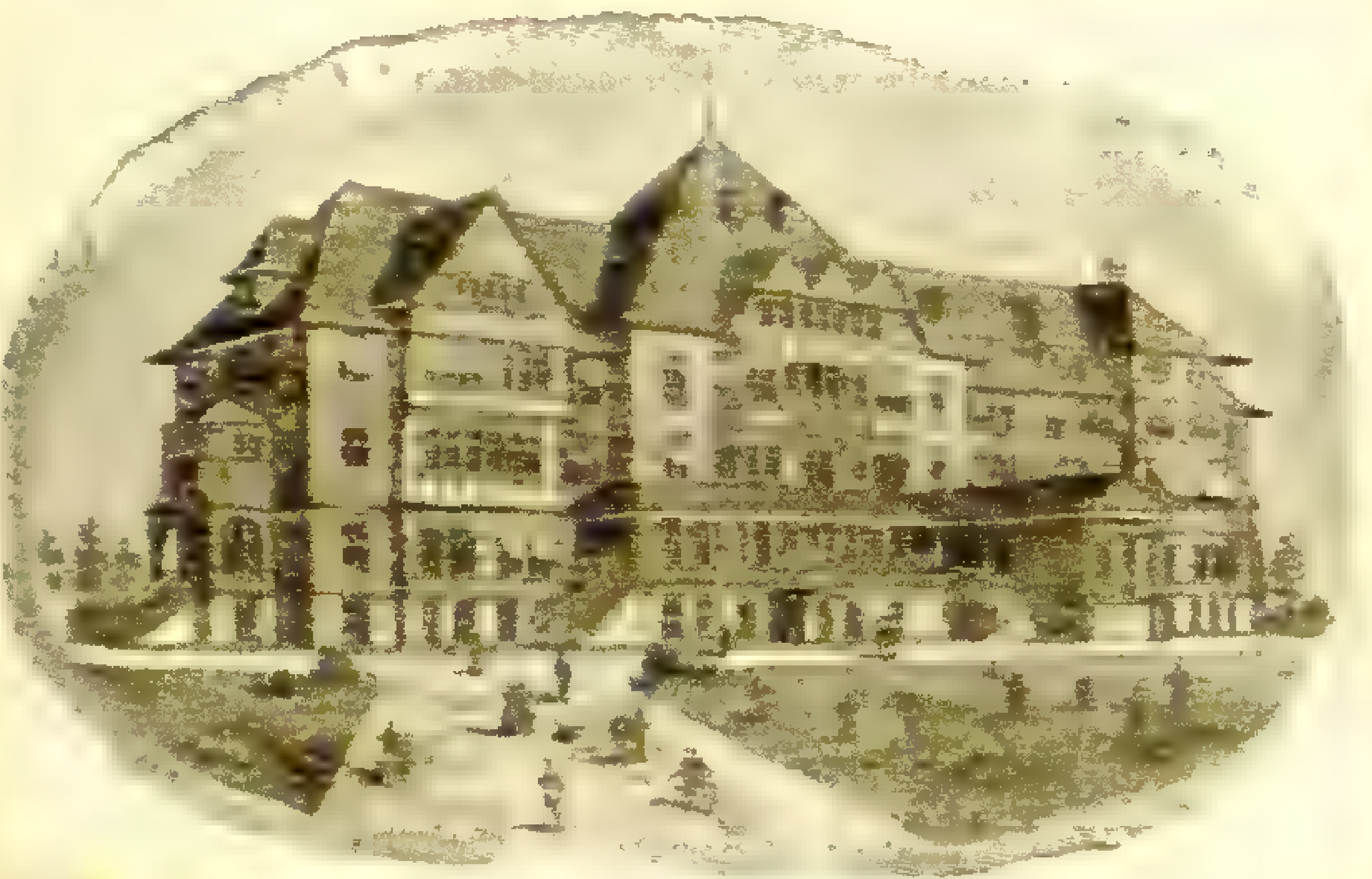

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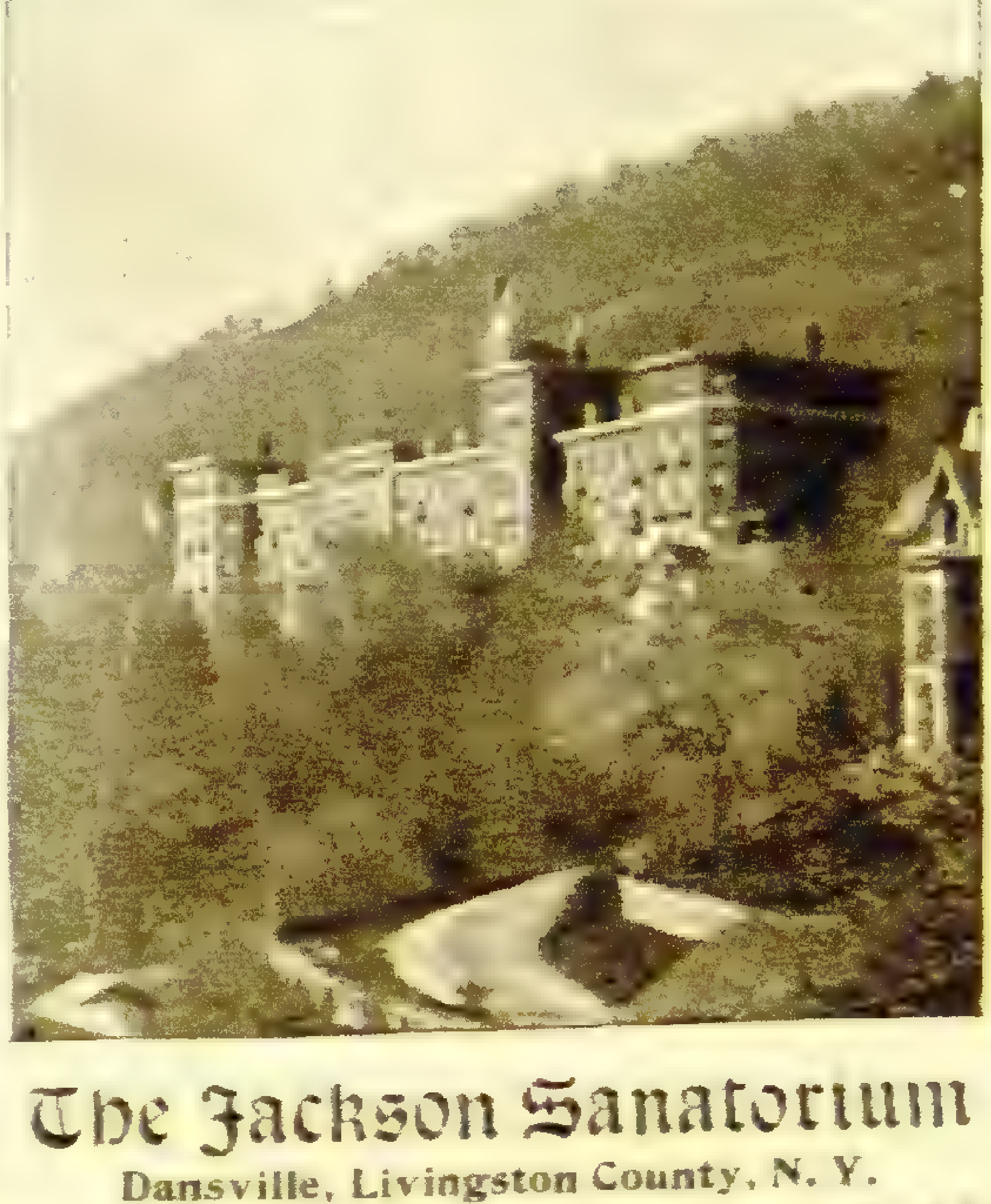

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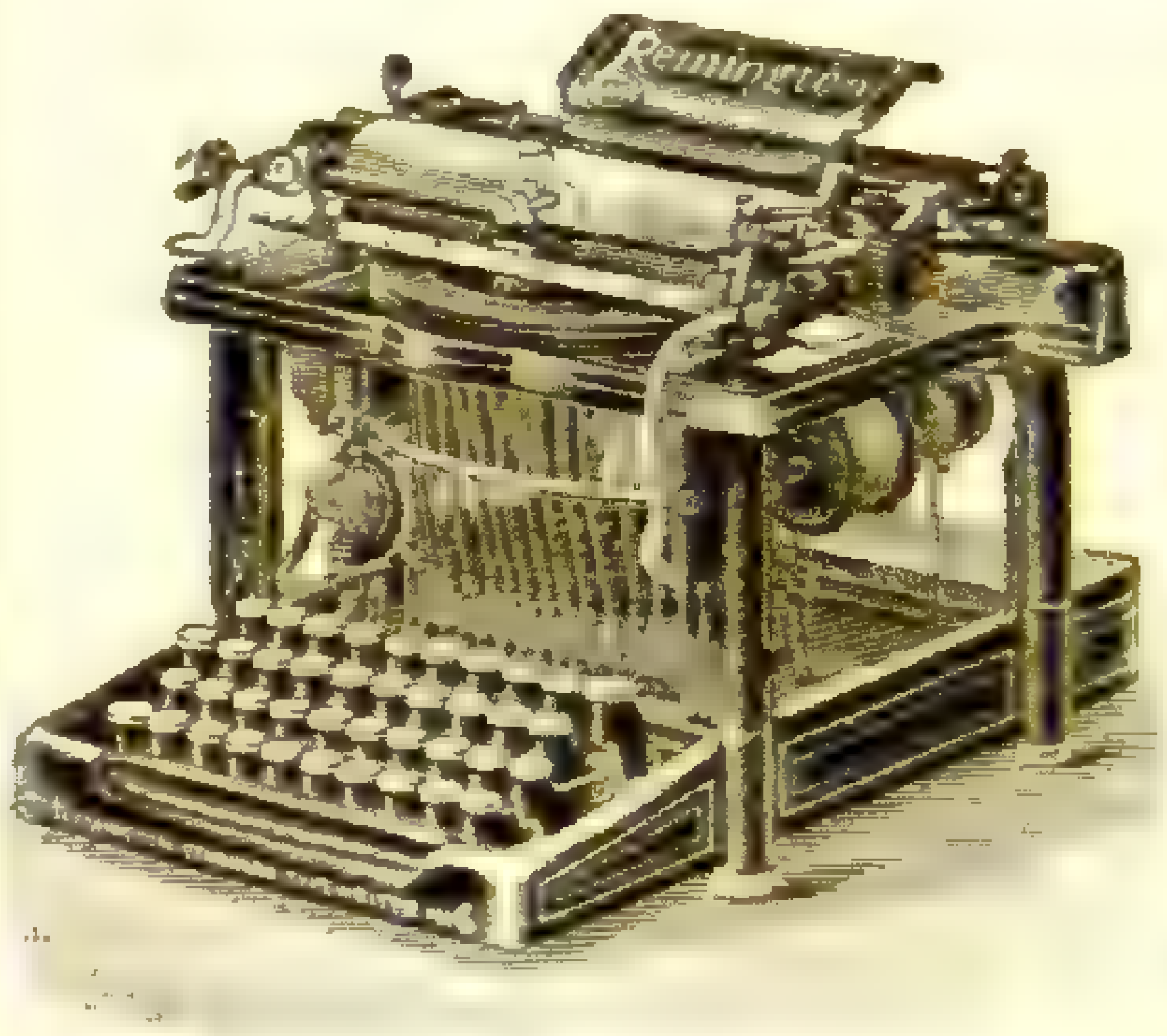

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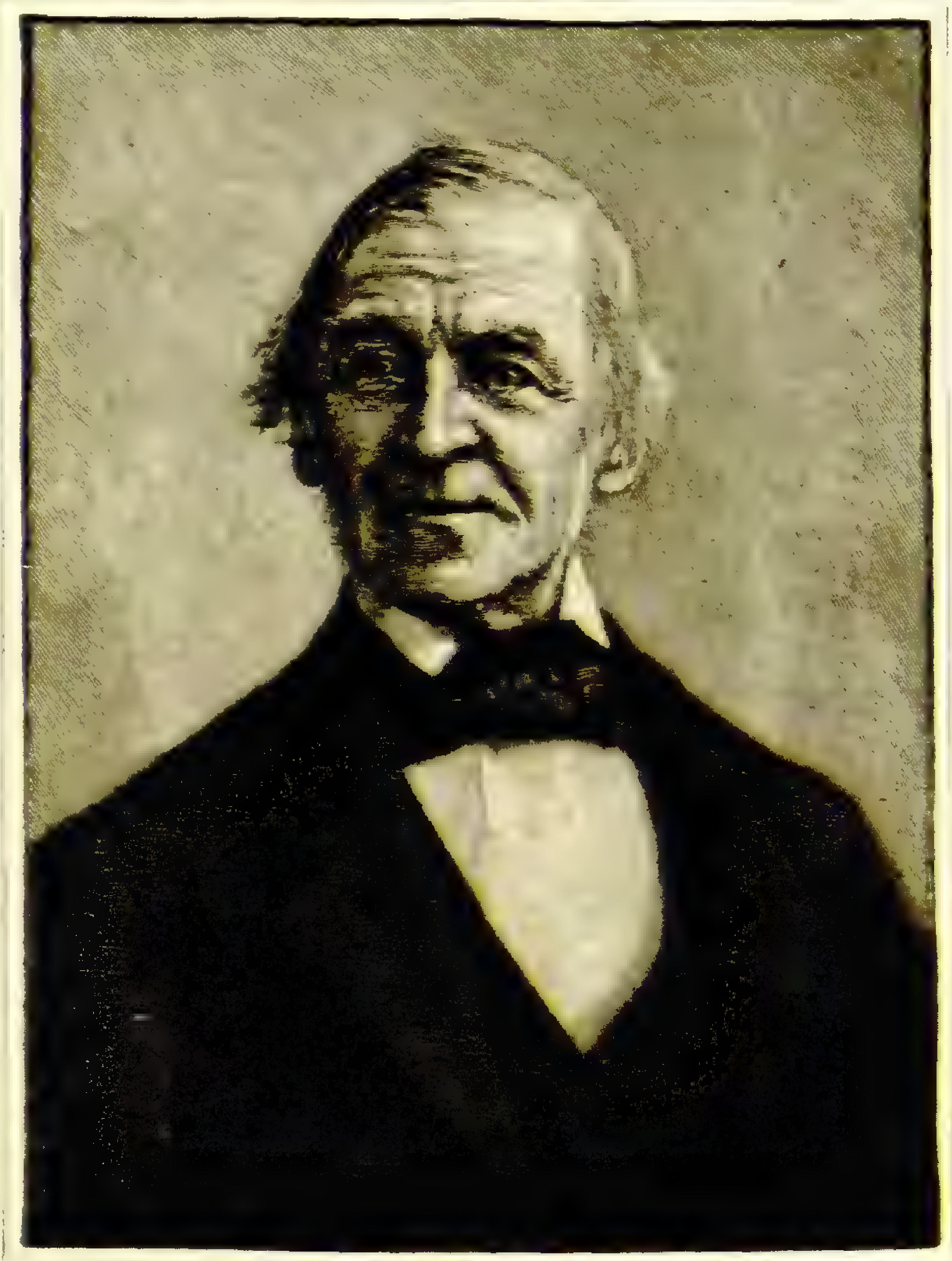

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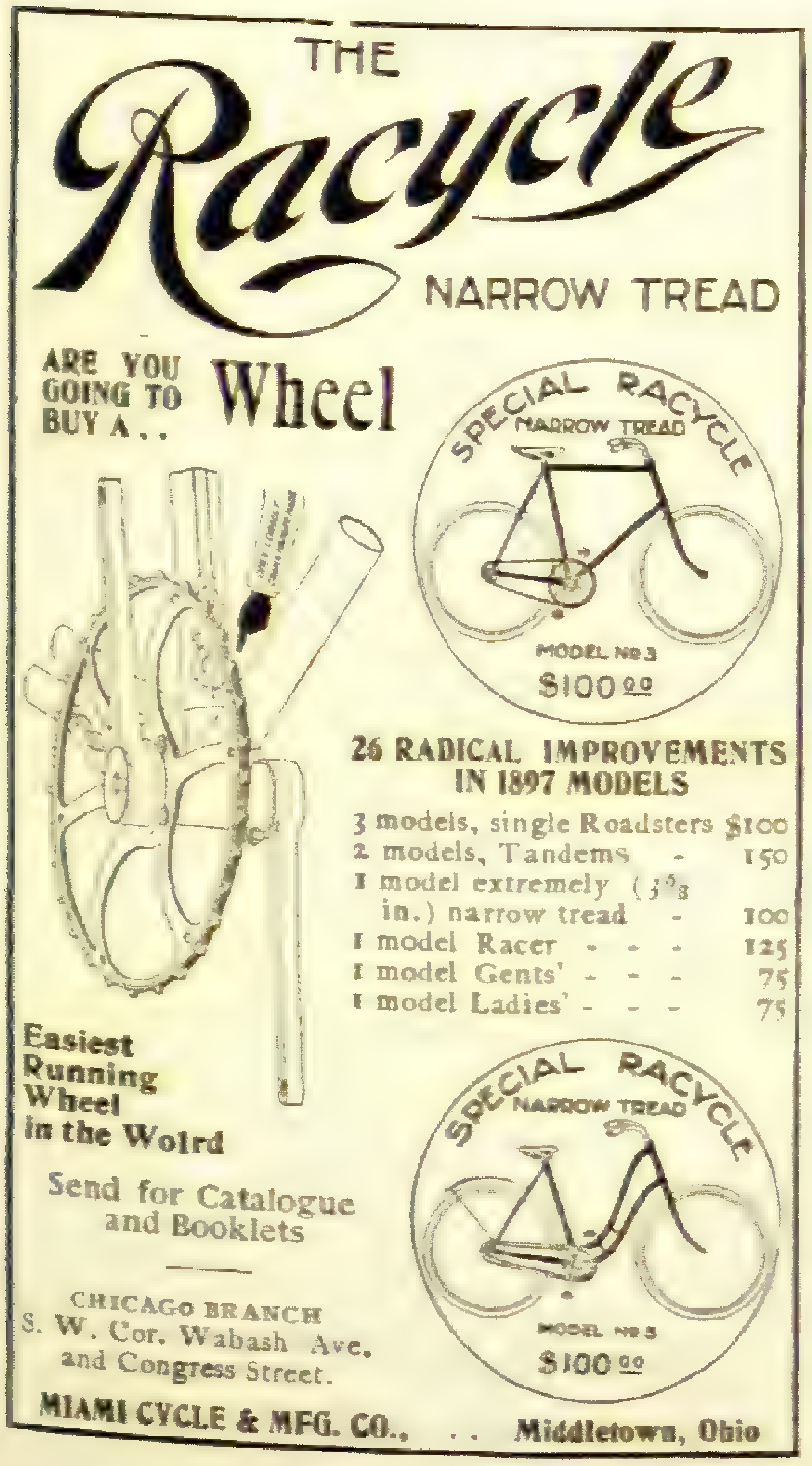
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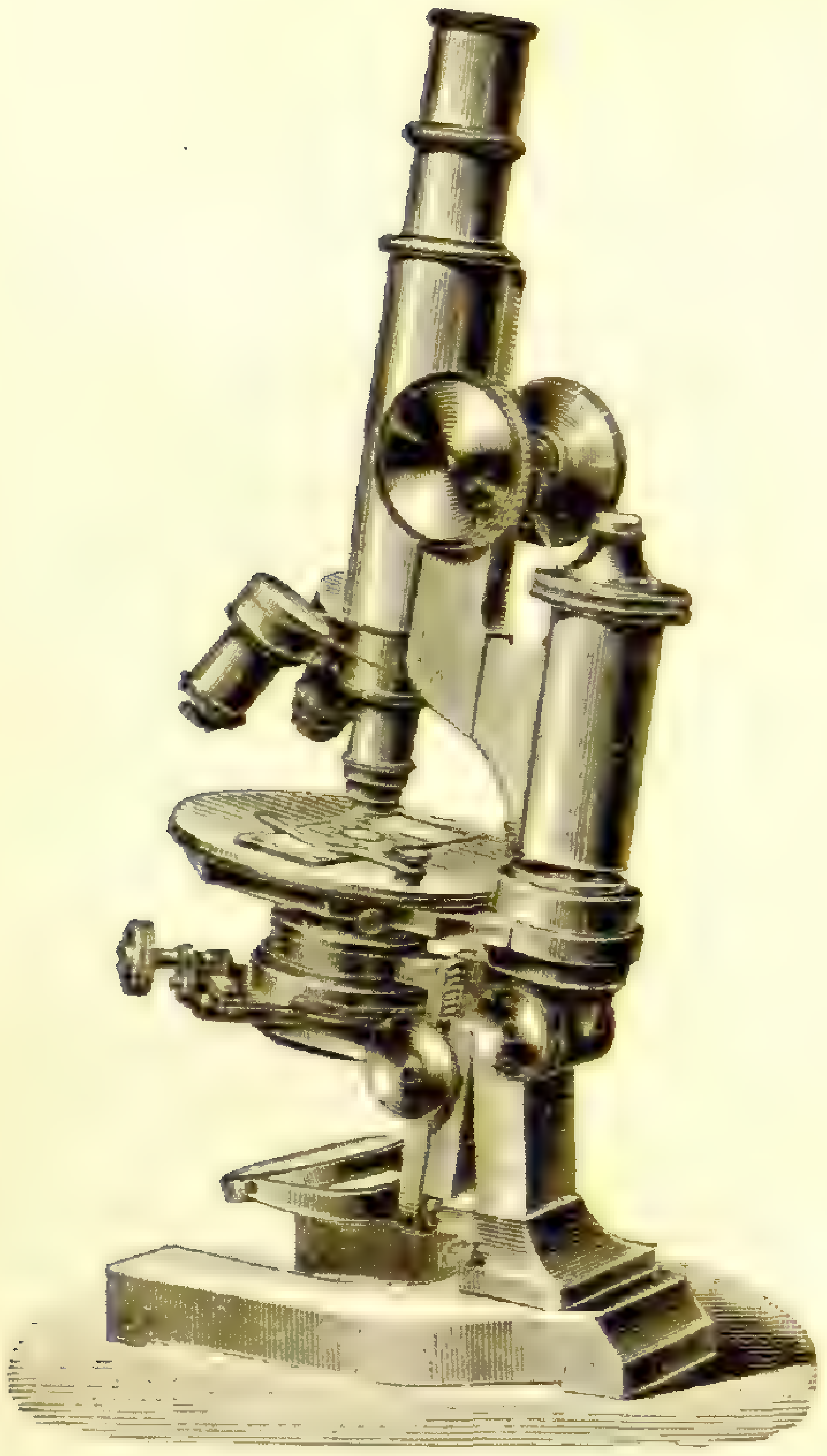

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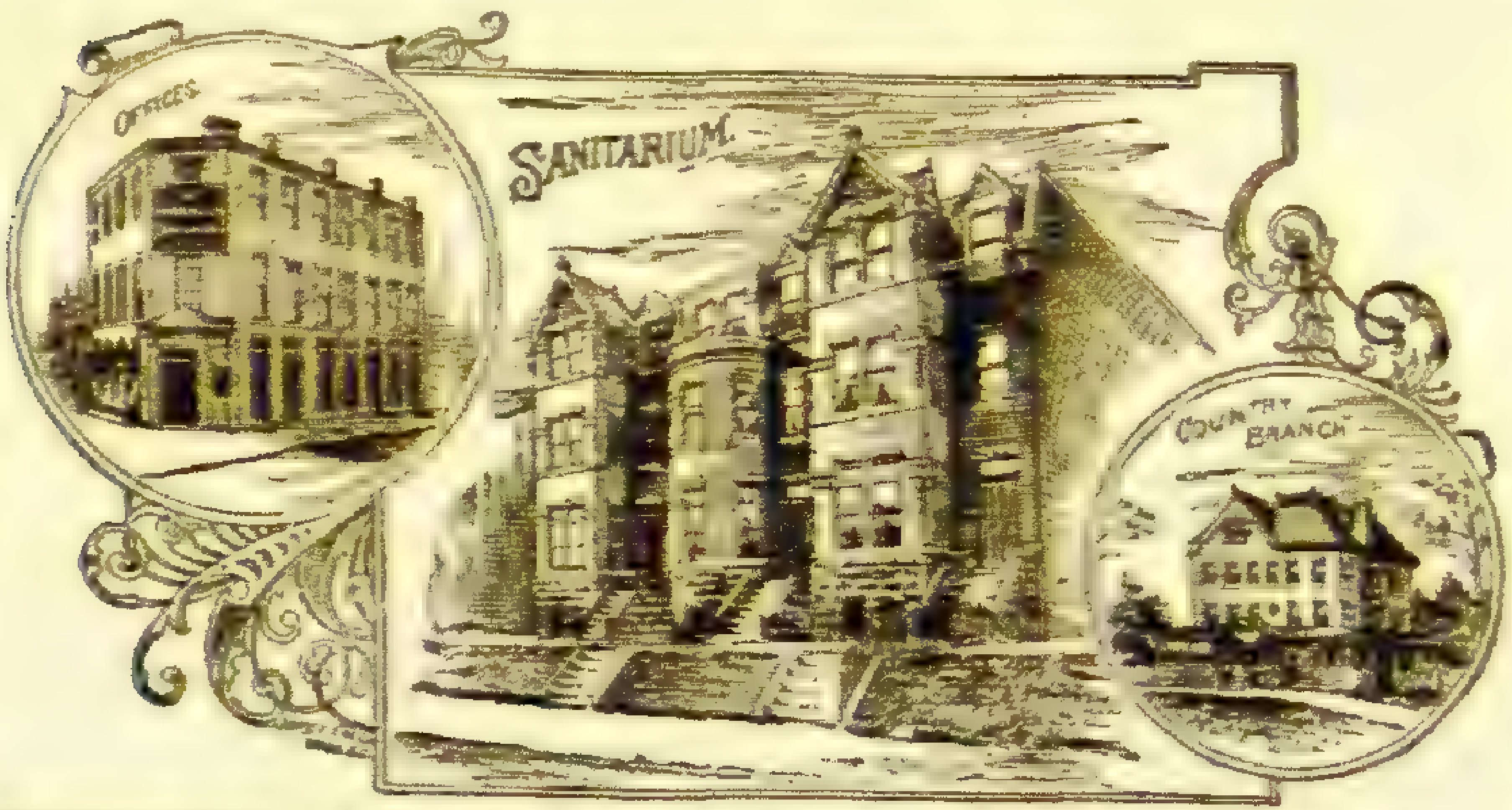

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Professor Evans, of Munich, performs for us a like service with Schiller. Prof. Maurice Francis Egan does the same with Calderon. Prof. Charles Eliot Norton of Harvard with Dante. Prof. Santayana with Cervantes. The historian Lecky with Gibbon. Charlton T. Lewis with Bacon, and so on. Never, it seems to us, was so much talent, such an array of eminent names pressed into service for the production of such compact and pregnant exposition and criticism.

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And so we might go on. But we think we have made clear to the reader that which struck us so forcibly when we looked into the Emerson section, namely, how finely Mr. Warner has, in his Library, succeeded in satisfying the great want which Emerson there so well voiced—that of a "professor of books." Exactly as the professor of chemistry or physics or astronomy or biology gives the student a view of the whole field of his science, the summary of its achievements, its great names and its great works, so Mr. Warner and his associates have given us the distillation not merely of the whole world's literature, in itself a colossal attempt, but, in addition, its history, biography, and criticism as well. It is only when we grasp its full import that we realize the truly vast and monumental character of the Library. It must assuredly rank as one of the most notable achievements of the century.

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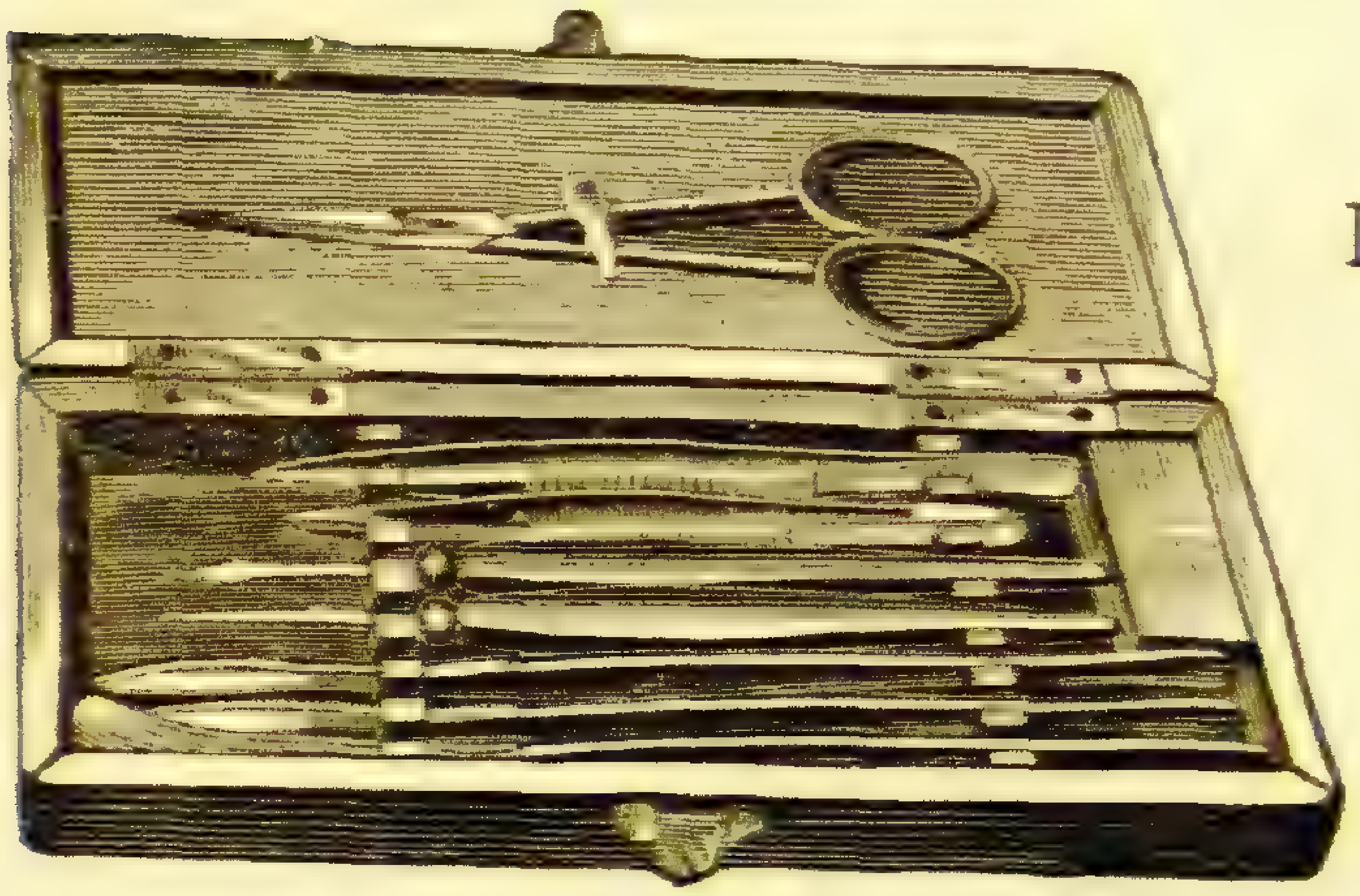

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BOTANICAL GAZETTE

MAY 1897

THE CURVATURE OF ROOTS.

D. T. MACDOUGAL.

(WITH PLATE XXVIII)

I. INTRODUCTORY.

In nearly all of the researches hitherto prosecuted upon "curvature" it has been assumed that movements of stems, petioles, leaves, petals, sepals and roots are accomplished by means of similar mechanisms, and the relation of the mechanical elements as well as the phylogenetic meaning of the movement have been ignored. Many writers have gone so far as to uphold the necessity of a common explanation for the mechanism of curvatures of unicellular, coenocytic, and multicellular organs, a necessity by no means obvious. It has been customary also to regard the curvatures of tendrils and other organs highly specialized in structure as well as in function as identical in mechanism with stems from which they are morphologically derived.

In the course of my recently published paper I have shown that great discrepancies exist between the features of curvature of the tendrils of Passiflora and those of stems so far as known. It is quite generally conceded that the curvature of stems is due to the elongation of the side of the member becoming convex, and that the tissues of the concave side are passive or nearly so. It has been shown, on the other hand, that in certain tendrils the formation of reaction curvatures is brought about by the contractile action of a mass of motor tissue lying in the concave side of these organs, and that the elements of the tissue are arranged with comparatively large intercellular spaces in a manner which allows of great and sudden variation in the water contained in the active cells. The action of such tendrils is therefore generally similar to that of pulvini. I have pointed out, moreover, that the features of curvature of the tendrils examined do not agree with those of the stems, and that all tendrils do not produce curvatures in the same manner. Attention has been called to the fact that pulvinar mechanisms may be held to be characteristic of organs in which rapid movement of great amplitude is desirable, and that slower and more general movements, where great tension is essential, are brought about by elongation of the convex sides of the motor organs (14).

In the course of the work upon tendrils, it was found necessary to make some comparisons of the action of certain dorsiventral members of this class with that of young roots of radial structure in the formation of reaction curvatures. The facts concerning the behavior of roots were not described or referred to, and during 1895 and 1896 work upon these organs has been carried steadily forward.

In a general comparison of the conditions prevalent in curving roots and tendrils, it is to be seen that while certain general mechanical similarities are present, yet the actual conditions are widely different. The fibro-vascular tissue is in the form of a central cylinder (more or less incomplete) in the tendril, while in the root it is either in the form of a rod or cylinder, but is not fully formed in the motor zone of the root, while tendrils do not acquire the power of reaction until the central cylinder is well differentiated. Furthermore, tendrils are furnished with a subepidermal layer of collenchyma tissue, sometimes two or three cells in thickness; a mechanical equivalent is wholly lacking from most roots. The greatest interest centers in the cortex and its relations to the water conducting or receiving spaces and vessels, since the force which gives rise directly to curvature arises or is released in the cortical parenchyma. In Passiflora the cortex of the tendril is supplied with a great abundance of intercellular spaces, which may receive any amount of water liable to be freed from the highly permeable motile cells. In other tendrils, in which intercellular spaces are not to be found in the cortex, the connection with the conducting tissue is direct and evident. I have recently called attention to the readiness with which large drops of water exude from the cut surfaces of active tendrils, which indicates the facility with which great quantities may be conducted to or from any point in the organ.[1]

In the motor zone of roots, however, no such intercellular spaces are to be found, and vascular tissues are not fully formed as yet; hence sudden or great variations in the water content of any of the cells in cross section is not possible. As necessary concomitants of these conditions, the movements brought about in roots follow the stimulus only after a much longer latent period, since movement can only be accomplished by alterations in the mass of the entire tissue together, while in tendrils the individual cells are capable of undergoing changes in form and size by giving off or taking up water from the intercellular spaces bounded by their outer walls.

II. HISTORICAL AND GENERAL.

The curvatures of roots have been regarded as identical with the movements of other organs, and the development of the present knowledge of the subject is to be found in the older literature under the title of curvatures. It will be conducive to clearness to recall the more important theses which have received support at various times, so far as the causes of curvatures are concerned. In the special paragraphs dealing with the curvatures of roots, the history of the researches bearing upon the action of these organs will be given.

Perhaps the first actual observation of facts concerned in the mechanism of curvatures was made by Hofmeister (9, p. 88). He found that the extensibility of the epidermal membranes of the convex side of an onion stalk was increased after geotropic stimulation, and this he believed to explain the curvature. However, he did not regard it as a phenomenon of growth in the present usage of the term, as is to be seen by the following quotation and the context:

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[1] On traumatropic curvatures of tendrils: A paper read before the Indiana Academy of Science, Indianapolis, Indiana, December 1896.

> Die auf Einwirkung der Schwerkraft eintretende aufwärts Krümmungen horizontaler oder gegen den Horizont geneigter Organe von Pflanzen geschicht dadurch, dass in der unteren Längshälfte des Organs die Dehnbarkeit diejenigen Zellmembranen zunimmt, welche der Expansion der in Ausdehungsstreben begriffenen Membranen Widerstand leisten.

As a matter of fact Hofmeister believed that the extension of the convex side of a curving root was similar to that shown by a pencil of soft wax.

Sachs, as a result of researches upon shoots and roots, brought out in his *Handbuch* in 1865 (26, pp. 92–96), and again in 1872 (23) and 1873 (24), agrees in the main with Hofmeister, but insists that the exaggerated extension of the convex side of curving organs is an actual growth. This idea was applied by workers in the Würzburg Institute to all curvatures. The development of information concerning turgidity led to an exaggerated estimate of the actual part played by its variations in curvatures.

Since that time, increased turgidity of the cells of the convex side, decreased extensibility of the membranes of the concave side, the aggregation of protoplasm on the concave side producing a shortening of the longitudinal and a lengthening of the radial axes, have each in turn been considered as the motive forces by investigators engaged with the subject. The thorough account of the matter given by F. Darwin in his presidential address to the section of biology of the British Association for the Advancement of Science in 1891 (6) renders it unnecessary to give the detailed steps here

It seems to be agreed on all hands that the curvatures are due to the exaggerated extension of the cells of the convex side, which is accompanied by a diminished extension or contraction of the concave side, dependent upon mechanical conditions. The chief contention at present concerns the conditions attendant upon the extension of the membranes of the convex side.

It may be due to the actual increase in the surface of the membranes, following and caused by the intussusception of new material, and the elongation of the convex side may be an actual growth, as maintained by Pfeffer (18) and others, and which, so far as growth was understood in 1865, is identical with the original explanation proposed by Sachs. On the other hand, the curvature may be due to an elastic and plastic extensibility of these membranes brought about by the induced action of the ectoplasm. Hofmeister's (9) theory of curvature agrees with this in the main, though purely mechanical causes were given for the increased extension of the membranes of the convex side. Sachs admitted the probability of changes in the elasticity of membranes, but he nowhere makes use of the idea in his researches upon the subject. Wiesner held the view that increased ductility of the membranes of the convex side, together with an increased osmotic coefficient, were the causes of curvature (30).

Strasburger also upheld the view that "growth" curvatures are due to increased ductility of the membranes of the convex side, and called attention to instances of changes of ductility in the walls of Oedogonium, the branching of Cladophora, and similar occurrences (29). Noll has recently brought some striking experimental results which, in connection with his previous work, go far to establish variations in plastic and elastic extensibility of the membranes as primary factors in the mechanism of curvature (16).

III. THE CURVATURES OF ROOTS.

I have indicated above that the constantly increasing mass of facts shows many differences between the phenomena attendant upon curvatures of roots and shoots, and it will be necessary therefore to recall the principal researches directed toward the mechanism of curvatures of roots, but it will not be profitable to go back of the work of Hofmeister. In the earlier researches, to which reference has been made above, Hofmeister sought to establish that in apogeotropic organs, such as roots, longitudinal tensions do not exist, and that downward curvature is purely mechanical, in confirmation of the theory originally proposed by Knight in 1806 (9). Frank, a few years later, demonstrated conclusively that the apogeotropic curvatures of roots are not mechanical, or due to the plasticity of the root tip and its own weight, but are due to active physiological processes (7). Despite the facts presented by Frank, Hofmeister maintained in a later paper:

> Alles ist so concludent wie möglich und lässt nur den Schlus zu, dass bei der Abwärtssenkung der äussersten Ende wachsender Wurzeln eine nahe hinter der Spitze gelegener Querabschnitt der Wurzel in ähnlicher Weise passiv dem Zuge der Schwere folge, wie ein zäber Brei oder ein Tropfen steifen Lacks (10).

Frank, however, firmly established the active part taken by the root in producing curvatures, and all later researches upon the subject are based upon this fact, and attention has been directed to the localization of the sensory and motor tissues, and the determination of the individual factors active in curvature.

Cieselski made an examination of the mechanism of the curvature of roots in 1871, in connection with his remarkable researches upon the general nature of irritability of these organs (1). He noted for the first time the greater density of the protoplasm of the concave side of the organs, a fact confirmed by Kohl in unicellular or coenocytic plants, and later in stems and tendrils by Sachs, and further examined by myself. The greater density of the protoplasm in the concave side of a tendril is not conditioned upon curvature, however, but is a distinct morphological character apparent in the earlier stages of development, before the special forms of irritability characteristic of these organs are exercised or even manifested. This aggregation of the protoplasm upon the concave side of isodiametric unicellular and multicellular organs has been described by Wortmann as the primary factor in the cause of curvature, an explanation which has been found inadequate for reasons which need not be discussed here. During a period from 1871 to 1873, Sachs devoted a large share of his attention to the curvatures of roots, and, so far as the mechanism of curvature is concerned, he concludes that it is due to the exaggerated growth of the convex side. Later researches by various investigators were turned toward other special phases of the subject and will be treated under the proper heads.

It has followed, as a result of the various investigations named above, that the immediate cause of curvature of roots and similar parts must be looked for in the cell wall, rather than in the ectoplasm. In certain tendrils, on the other hand, the immediate cause of the curvature is the alteration in the motility and permeability of the ectoplasm. It is of course true that the changes in the cell wall in roots must be induced by the ectoplasm.

It has appeared to the writer that the more important facts concerning curvature might be obtained by an actual examination of the changes of cell contours and wall characters in the motor zones of the curving organs, in the manner which has yielded such decided results in the study of tendrils, and which has been applied to some extent by Kohl in unicellular organs, and especially by Noll in his study of stems. The result may apply to all isodiametric organs, but the writer does not wish to make such strict and inclusive application, since it is conceivable that the disposition of the mechanical factors, as well as the development of the various forms of irritability, would necessitate in many cases a somewhat different method of procedure.

IV. DEVELOPMENT OF IRRITABILITY IN ROOTS AND SHOOTS.[2]

The emergence of the plant from an aquatic to a terrestrial habitat, in connection with the loss of motility in an extremely early stage of its development, was marked by several radical changes in its physiological organization, due in greater part to the alterations in the conditions attendant upon the nutritive processes.

The economical acquisition of nutritive substance in proper

[2] Given in an address before the Botanical Club of The University of Chicago, January 18, 1897.

amount is a fundamental necessity of every organism, and to the conditions attendant upon the performance of the nutritive functions must be ascribed the chief causes underlying the development of the plant body. The chlorophyll processes, therefore, have been the paramount factors in the development of the shoot, and the necessities attendant upon their proper performance will account for the method of differentiation of the shoot, and the very great degree of segmentation and branching which it has attained. The segmentation of the shoot has made possible not only the profitable display of ever increasing areas of chlorophyll bearing tissues, the proper elevation, orientation, and isolation of the reproductive organs, but also a separation of the minor functions and the differentiation of special organs for their performance. The separation of nutritive, reproductive, and other functions has been accompanied by a contemporaneous separation and development of the special forms of irritability which are concerned with the forces dealt with by each organ. Thus, for example, the most important factor in the processes carried on by the leaf is the radiant energy derived from the sun. As a necessary concomitant of the advantageous use of this energy, the leaf has developed a strongly marked irritability to light and heat rays, and, as a result of the relations of the organ to the horizon in response to its heliotropism and thermotropism, it has acquired in some instances also a trace of geotropism.

In the accomplishment of the reproductive processes, an incidental condition is the transference of the pollen from its place of formation to the surface of the stigma in the same or other flowers. In a great majority of instances the relation of the line joining the anther and the stigma to the vertex or horizon is of the utmost importance, whether the pollination is accomplished by insects or automatically by air currents, and a well marked geotropic reaction is therefore generally exhibited by flowers with the motor zone located in the peduncle. These organs also show minor heliotropic reactions.

The same process of analysis may be applied to the entire shoot, with the general result that each organ will be found to respond to a number of forces generally limited to two or three, though, of course, instances are not lacking where a great number of forms of irritability are found to reside in the same organ, as, for example, in tendrils. In such instances, however, the excessive number of the forms of irritability has been developed to meet special ecological conditions, bearing upon both the nutritive and reproductive processes, either directly or indirectly. Furthermore, the organs of the shoot may acquire also the power of special reactions to internal forces or stimuli, such, for example, as the carpotropic movements.

In a consideration of the localization and distribution of the property of irritability attention is to be called to the fact that the conditions concerned in the nutritive processes of the shoot show an invariably wide diffusion in space, while varying from zero to maximum in time. Carbon dioxide exists everywhere in the atmosphere in uniform proportions and bathes every part of the shoot. Sunlight is bounded only by the horizon line, and may reach any surface of the shoot in diffuse form. The chlorophyll processes may then be carried on by the subepidermal tissues in any portion of the shoot, and as a consequence a greater proportion of the peripheral protoplasm of the shoot has developed an irritability to sunlight, although it may not always be manifested by organic or external movement, or other response.

The researches of Rothert have shown that a large part of the surface of the leaf of Avena and Phalaris exhibits a heliotropic irritability, and some experiments in my own laboratory, by Mr. R. E. Squires, demonstrate that the laminae of dicotyledonous leaves exhibit an equal distribution of sensitiveness over their entire surface, and that the leaflets in a compound organ are strictly coordinate and equal with respect to their irritability (22). Those branches of the shoot that have developed special or ecological adaptations exhibit an extension of the irritable surface corresponding to the limited diffusion or occurrence of possible stimuli, modified to some extent by the character and inclusiveness of the reaction.

Although the motor zones of the shoots do not include as large proportions of the plant as the sensory zone, yet the distribution is fairly general throughout the growing regions. It is possible to induce curvatures in some stems in which growth has almost entirely ceased. The curvature, however, is accompanied by a revival of the growth activity.

The functions of the root are not so numerous as those of the shoot, and while the efficient performance of the necessary amount of absorption to keep pace with the increase in mass and surface of the shoot has demanded a repeated branching, yet no segmentation like that of the shoot has occurred. The secondary function of the root, fixation, is purely mechanical, and the separation of the two functions has not been effected by a localization of the functions in different organs, but is an incident to the stage or degree of development of these organs. Physiologically the basal portion of roots sustains a relation to the absorptive system similar to that of the basal portions of typical stems to the chlorophyll bearing and reproductive organs.

In the earlier stages of growth any given portion of the root is purely directive, next absorptive, and in later periods is exclusively fixative. Only in certain special classes of aerial and other plants does a separation or isolation occur. The stem, on the other hand, is at first directive, and then fixative, and does not in any stage of its existence assume the relative importance which is to be ascribed to every portion of the root in one period of its development.

In explanation ot this different method of development it is to be said that the roots have always been surrounded by much more uniform conditions in time than the shoot, and in consequence have met the necessity for a much narrower range of adaptive modifications. But while the range and rapidity of variation of outward conditions affecting the roots have been much less than those of the shoot, yet the inequalities of diffusion and distribution of the nutritive factors are much greater than those affecting the shoot. Water and food substances lie below the surface of the substratum, and the root has developed a highly marked form of geotropism, which enables it to penetrate the soil. Water and food substances, however, are by no means so uniformly distributed as sunlight and carbon dioxide. While water exhibits a fairly horizontal distribution in quantity, yet so far as its actual availability is concerned differences corresponding to the physical characteristics of the soil are to be found. The vertical distribution is modified in the same manner. The mineral food substances present no system or uniformity of distribution whatever. As a matter of fact the masses of food substances may and do lie in all possible directions from the absorbent zone of the apical portion of the root. In order to reach such irregularly distributed masses of nutritive substances it is evidently necessary that the root should develop an irritability to a much greater number of forces than any member or organ of the shoot, and furthermore it is evident that all the forms of irritability thus acquired must be located in the apical portion of the root, the proper directive activity of which only is concerned with the absorptive processes. The coincidence of several forms of irritability within such narrow limits has necessitated differentiations in another direction from that offered by the shoot. The differentiation of the shoot resulted in a tendency to separate the different forms of irritability with their attendant mechanisms. The increase of the efficiency of the root has resulted in the acquisition of a constantly increasing number of forms of irritability, within a limited mass of tissue, the mechanism of which must necessarily be identical. Still further this has resulted, of course, in the differentiation of the separate parts of the mechanism and increase of its delicacy of reaction. This may be held to apply to all similar arrangements, especially in the ecological reactions shown by the so-called "sensitive" plants.

V. IRRITABLE ORGANIZATION OF THE ROOT.

On account of the fact that the irritable mechanism of roots is located in the embryonic region of the organ, no distinct morphological characters can be assigned to the various organs of irritability. As a matter of fact the differentiation is entirely physiological, as it will be, indeed, in all organs in which the irritability is only a temporary character. It is therefore impossible to do more than to determine the relative position of the masses of cells in which in turn the various parts of this complex function are located.

VI. FORCES ACTING AS STIMULI IN ROOTS.

In accordance with the above it is found that the roots react to geotropic, heliotropic, thermotropic, hydrotropic, galvanotropic, rheotropic, chemotropic, and traumatropic stimuli, besides exhibiting rectipetality or autotropism. These terms are used in an inclusive sense, without reference to the phase of reaction under each form. Under traumatropism are included all of the reactions to mechanical stimuli, resulting in contact or injury, as well as the action of corrosive chemicals. It is to be noted that many roots do not exhibit all of the forms of irritability enumerated.

In the study of the mechanism of curvatures which forms a part of this paper I have examined geotropic, rheotropic, and traumatropic curvatures, and since no essential difference could be detected, chief attention was paid to curvatures obtained by geotropism.

VII. THE SENSORY ZONE.

The history of the researches bearing upon the location of the sensitive tissue of the root is a long one, and begins with Darwin's experiments in which decapitated roots were found to be incapable of response to the forces to which they usually react (4). The pathological condition induced by the decapitation made the conclusion that the sensitive tissue was located in the extreme apex unsafe, and it was bitterly opposed by Sachs (28), Detlefsen, and others, and it was not entirely determined beyond doubt until the recent brilliant experiments of Pfeffer (21), in which it was shown that if a root were forced to grow in a bent tube in such a manner that the section 1 to 2^{mm} in length, including the *punctum vegetationis*, assumed a position at right angles to the axis of the basal portion, and then placed in such position that the bent apex was in a position of equilibrium, no excitation occurred. A concise history of the various researches dealing with the localization of the sensitive tissue, previous to the experiments of Pfeffer, was given by Rothert in 1894 (21).

The result of all the investigations upon the matter shows that the mass of sensitive tissue is located in the peripheral portion of the *punctum vegetationis*. The excision of a mass of cells not exceeding $.5^{cu\ mm}$ removes this zone of sensitive tissue entirely from the roots of *Zea mais*, and since the penetration of the growing zone beyond the outer layers produces other effects besides those due to irritability, it may be assumed that the sensitive tissue is in the form of a cup with walls consisting of a few layers of cells only. Furthermore, the cells of the walls of the cup acquire the special power of reception of outward stimuli shortly after their formation, and retain it for a short time only, during which time the *punctum vegetationis* moves forward and forms new layers in front of them. This period in most roots extends over a few hours only. After this time, these cells lose the power of converting impinging forces into impulses, and retain only the primitive forms common to all. Whether or not this specialized mass of cells, or rather the cells in the specialized stage, are arranged as a complex organ, in which the individual and separate action of the cells is necessary, or whether each individual cell is capable of giving rise to the force constituting an impulse, has not been ascertained, since insurmountable technical difficulties stand in the way of a determination of the matter. It appears more likely, however, that the concerted and organized action of a number of the protoplasts of the irritable zone is indispensable, especially in such reactions as those of geotropism.

This conclusion is favored by results obtained by Spalding in his study of traumatropic curvatures (28). He says:

> It soon became evident that the nature, direction, and extent of the wound

constitute an important factor. . . . . If the tip of a root is cut off square across, it does not exhibit traumatropic curvatures, but if cut obliquely it becomes curved, provided the cut is made to the right depth. . . . . It is plain that in order to induce traumatropic curvature with certainty by oblique cutting away of tissue at the apex, the cut must be made deep enough to affect the growing point itself. It is perfectly plain that the root cap may be cut deeply without curvature following.

In my own work some experiments were made in an effort to bound the sensory zone. A root tip of Zea, branded in such manner that nearly all of the root cap was killed, as well as a sector of tissue beginning $.5^{mm}$ back of the apex of the growing point and extending obliquely across, intersecting both sides of the cylinder of periblem and including the entire apical part of the growing point (*fig. 1*), exhibited marked curvature a few hours later.

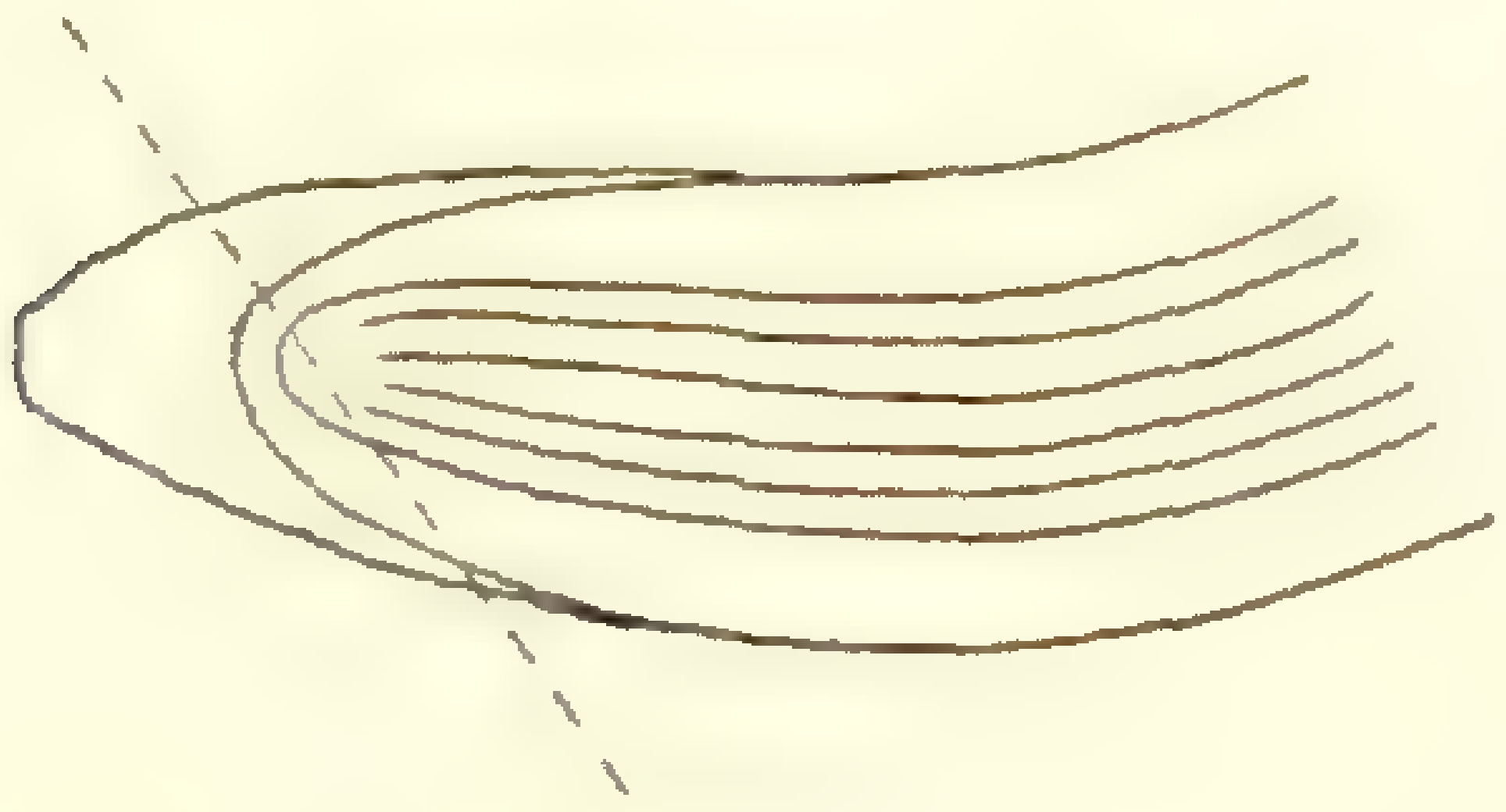

FIG. 1

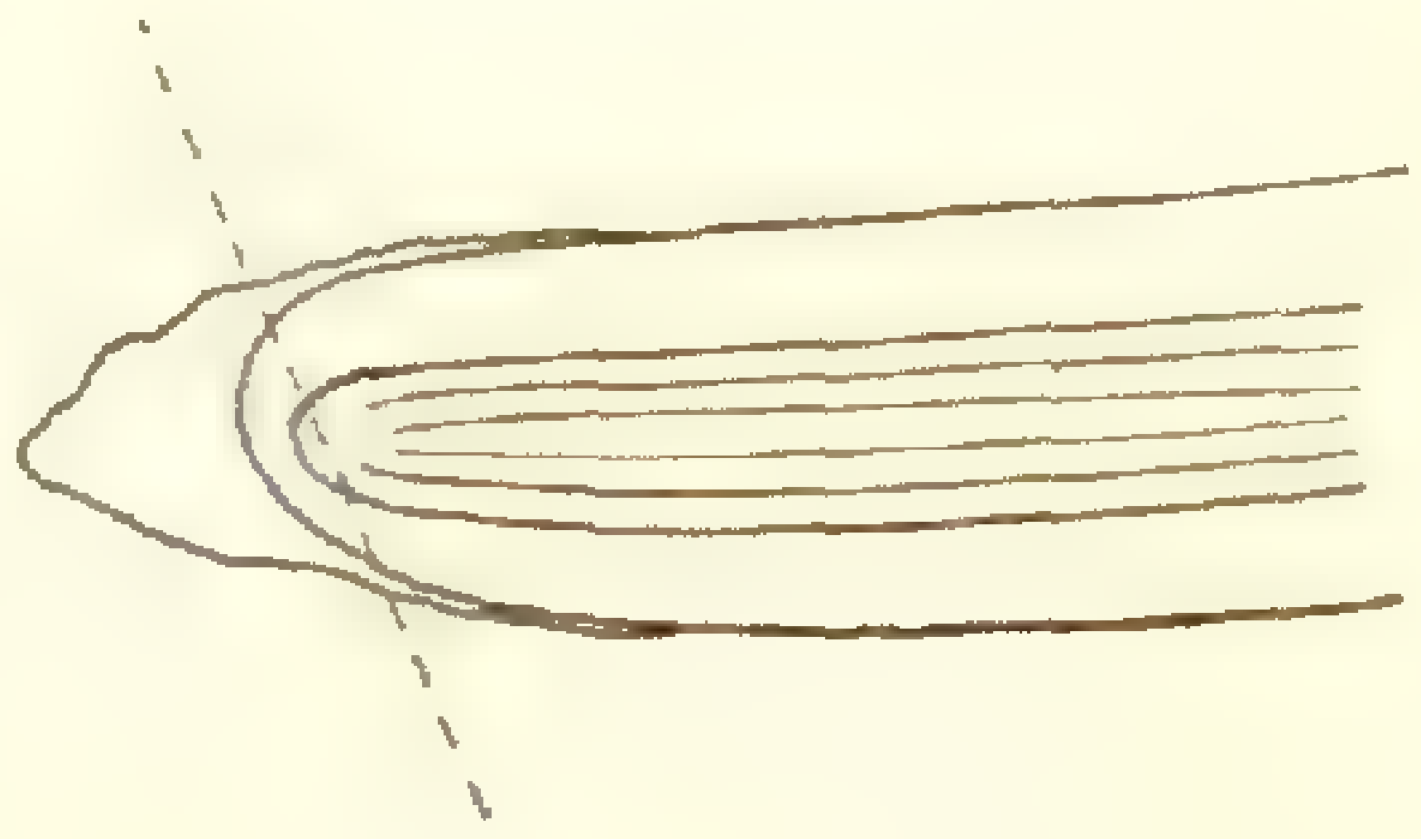

FIG. 2

FIG. 1. Diagram showing extent of injury by branding, producing a curvature in a root of Zea.

FIG. 2. Diagram showing extent of injury by branding, producing a curvature in a root of Pisum.

In another instance, a root of Pisum, branded in such manner that the entire root tip and a sector $.4^{mm}$ in length (axially) cutting both sides of the cylinder of periblem at an angle of 30°, produced a curvature (*fig. 2*). A strong curvature was exhibited by a root of Phoenix from which a thin slice from the outer layer of the cortex back of the *punctum vegetationis* had been removed (*fig. 3*). In like manner, a radial incision in the cortex of a root of Arisaema at a distance of 1.5^{cm} from the tip gave a decided reaction (*fig. 4*). These results suggest that the sensitive zone includes that portion of the periblem lying basal to the perpendicular through the axis of the root at the growing point, and that this tissue is in the form of a cone shaped cup, the rounded bottom of which is extremely thin, or is wholly absent.

As a matter of fact, it appears from the results at hand that the *punctum vegetationis* does not form a part of the sensory zone. Some further investigations upon this point are in progress. It is highly improbable that the growing point, shielded by the thick root cap, should have acquired any special irritability to external forces, particularly of a mechanical nature. It is to be remembered that the specialized receptive zone of the root tip is a physiological, not a morphological differentiation. This zone resides in the embryonic tissue during a limited number of hours only, and moves steadily forward. Furthermore, this single zone is capable of the reception of stimuli of all the classes to which the root as a whole reacts, eight in number. It is to be noted that in irritable mechanisms of such character the phenomena of accommodation may not occur. The residence of the special forms of irritability is too brief to permit the protoplasm to recover from continued stimuli. In the root the period of irritability is but little greater than the latent period.

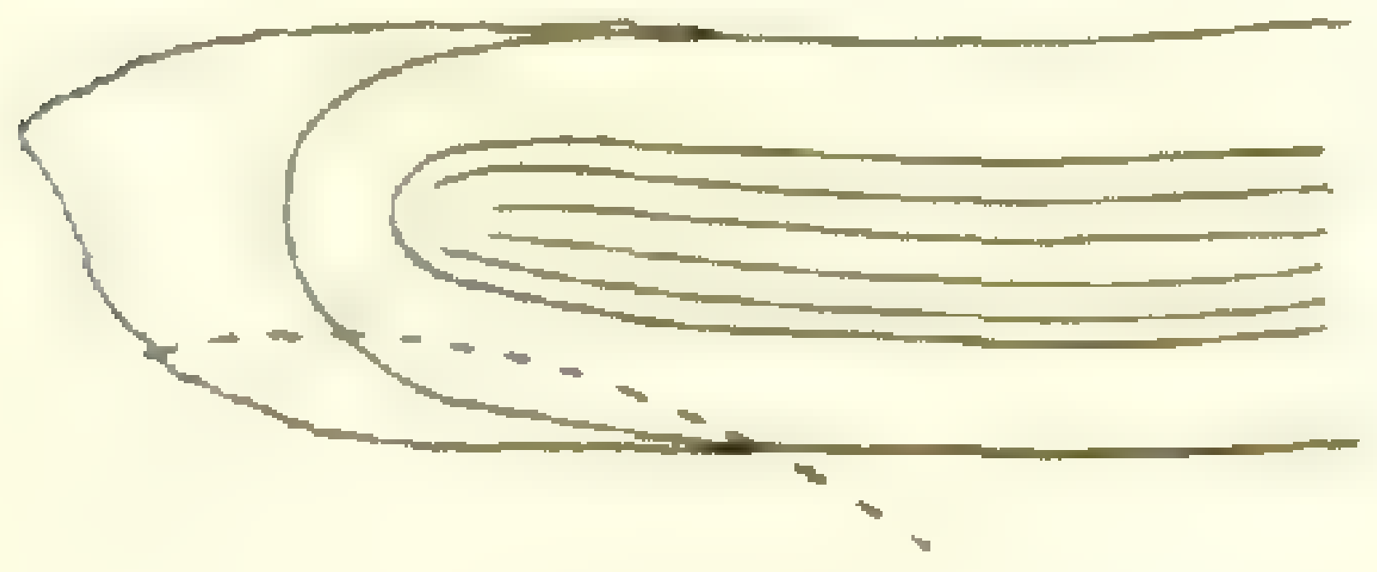

FIG. 3

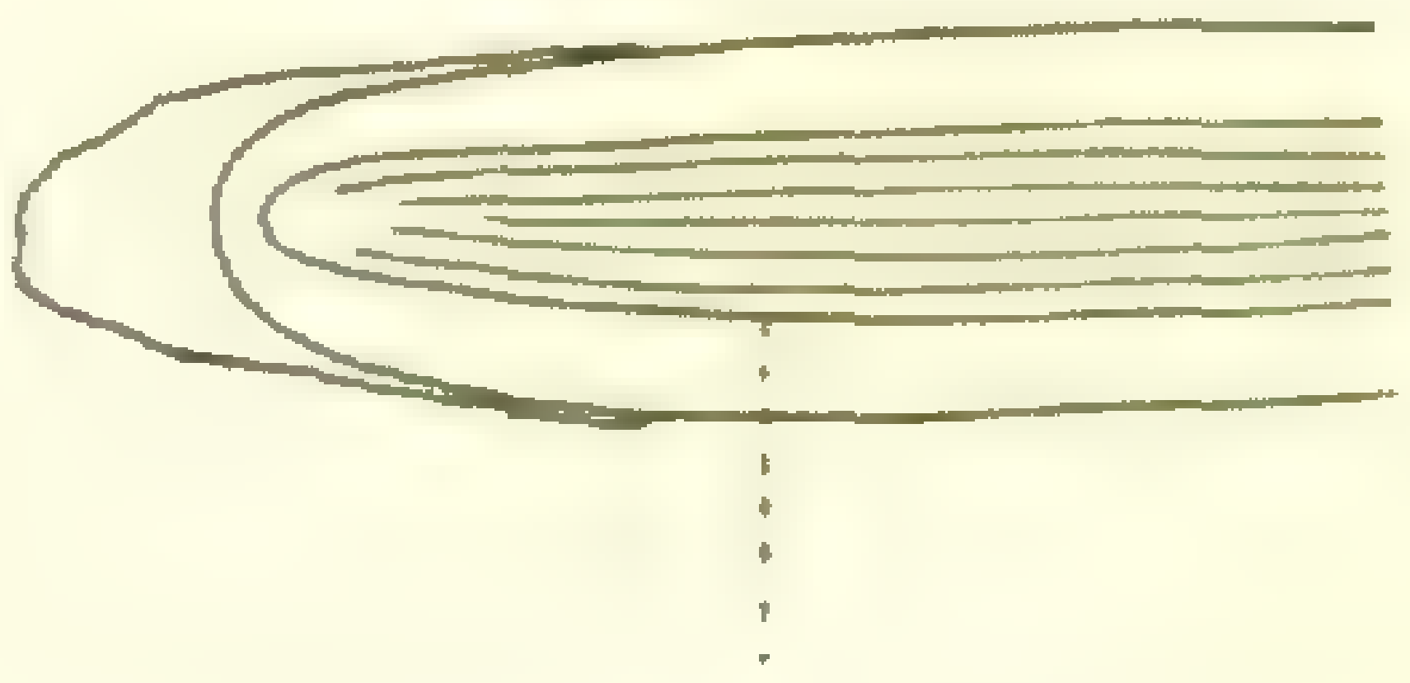

FIG. 4

FIG. 3. Diagram showing extent of excision producing curvature in a root of Phoenix dactylifera.

FIG. 4. Diagram showing location and extent of incision producing curvature in a root of Arisaema triphyllum.

This region, capable of receiving special stimuli and originating motor impulses, has been termed the *perceptive zone*. I am unable to trace such an application of the term to its origin, but find that it has been in use in the publications of the botanical institute at Leipzig since 1893 (18). Such a usage of the term is not in harmony with the meaning of "perception" in the domain of psychology, since here it is used to denote a much higher form of activity, coupled with the presence of consciousness, or a much higher form of consciousness than is exhibited by roots, and the use of the word "perception" to denote any of its functions is therefore wrong and misleading. It is evident that the most appropriate term must be derived from the term *sensor.* The following use of the term by Clifford (3, **2**: 108) will illustrate quite fully the significance of the term:

> Various combinations of disturbances in the sensor tract lead to the appropriate combination of disturbances in the motor tract.

I have therefore denoted this specially irritable zone as the *sensory zone.* Some sharp distinctions exist between the general nature of the sensory zone of roots and that of tendrils and other special forms of irritable organs, in which a similar coincidence of several forms of irritability occurs. In the latter, the sensory zone is composed of morphologically differentiated protoplasts which retain their directive function during the entire period of activity of the organ of which they form a part, and although they give rise to impulses in response to several classes of stimuli, the reaction, with minor modifications, is invariable in kind and direction, and shows differences in degree due to the specialization of the motor tracts, which retain their function during the activity of the member of which they are a part. In roots, on the other hand, the sensory function moves steadily from protoplast to protoplast, as also does the motor function; and while the sensory zone converts many different classes of stimuli into motor impulses, yet the reaction is by no means invariably the same. The root may move toward or away from the different stimuli, or may move toward an amount of stimulus, constituting its optimum, and move away from a greater intensity of force. The greater inclusiveness of the purpose of the root is of course accountable for the wider range of reaction; and it is also to be said that it is a natural result of morphological necessity and physiological economy.

VIII. THE LATENT PERIOD.

The latent period embraces the time necessary for the conversion of the external force into an impulse, the transmission of the impulse to the motor zone, and the changes in the motor zone necessary to exert a bending force upon the root.

Although no special and exact measurements of the latent period were made in my experiments, yet it was found in plants, such as Pisum and Phaseolus, in which a primary medulla is formed and the mechanical tissues of the motor zone are thus in the form of a tube, the latent period was from three to five hours. On the other hand, in such roots as those of Zea and other monocotyledonous plants, in which the fibro-vascular tissue is in the form of a solid cylinder of less diameter than the tube in Phaseolus, it would present far less resistance to the action of the cortex. The latent period of Zea is from one to two hours. It is to be borne in mind that in all such observations the roots were under conditions which retard curvature. The latent period of roots in the soil must be somewhat less. Chas. Darwin notes distinct curvatures in the roots of many plants, in response to contact, in five to nine hours (4). The movement had made great progress (20–30°) on the lapse of this period after excitation. It is evident that wide variations will be shown in the length of time between excitation and reaction.

The manner in which impulses are conducted from the sensory to the motor zone is a matter which may not be determined exactly. The entire mass of protoplasts between the sensory zone and the motor zone are in a state of intense metabolism and vigorous growth, and are not entirely separated by the imperfect and newly formed walls. The distance separating the two zones may be as great as 1 to 2^{mm} in some roots in a state of very rapid elongation, while in others the two regions must nearly join; indeed, it is conceivable that they may overlap in certain cases (see "motor zone").

The determination of the method of transmission is a matter which must wait upon a great advance in knowledge of the physiology of the cell.

The assumption is justified that the great difference in the latent period is due to the greater mechanical inertia to be overcome in Phaseolus than in Zea, and that only a comparatively small proportion of it is concerned in the production and transmission of the impulse. That many changes preliminary to curvature do ensue is suggested by the results of Kirchner (11), who found that a marked difference was to be noted between the specific gravity of the tissues of the convex and concave sides of a root in one to two hours after stimulation, or long before the slightest curvature was to be seen.

IX. THE MOTOR ZONE.

The region of the root which exhibits curvature is to be termed the *motor zone*. Hofmeister asserted that the region capable of curvature occupies a position immediately back of the root cap, and found by twenty measurements that it lies at a distance of 1.75 to 3^{mm} from the tip of the root cap in roots of Pisum (10). Frank (8), N. J. C. Müller (15), and Cieselski (1), on the other hand, held that the curvature occurs in the region of greatest growth; and Sachs (27), in consideration of these conflicting views, asserts that the entire growing region of the root participates in the action, and that naturally the region of most rapid elongation exhibits the curvature of the shortest radius. The proper determination of this matter is of the greatest importance in the consideration of the mechanism of curvature. If the entire growing region participates in the movement it would be a very weighty bit of evidence in favor of the theory that curvature results purely from growth, to the exclusion of any idea of ductile extension. If, however, only a special region is concerned the case is left open for the interposition of specialized action on the part of the root. This specialized action might consist of accelerated growth or might consist in changes in extensibility of the walls.

An examination of my preparations reveals the fact that the region of greatest curvature lies in that portion of the root where the energy of the periblem or cortex has become diverted from cell division to cell enlargement, and where the walls exhibit the greatest extensibility. The forward edge of this zone lies at a distance of 2 to 2.4^{mm} from the forward limit of the *punctum vegetationis* in Zea. The measurements were made of sections of roots which had been under geotropic excitation for three hours and were then killed in chromic acid. During this time the region forward of the motor zone had doubtless increased in length at its usual rate, and the measurements thus include an increment of growth amounting to 10 to 15 per cent. of the total length given. This fact has been wholly disregarded in the determinations hitherto made of the location of the motor zone. The distance from the tip to the region of curvature often measures 8 to 20^{mm} twenty-four hours after excitation. The excitation sets certain forces in play in a region at a certain distance from the tip at the time of excitation. The apical region continues to elongate, and by the time the motion becomes visible the apex has extended its own length considerably.

That the curvature does not extend over the entire region of growth according to its condition is to be seen in a comparison of the curvatures obtained mechanically and those resulting from the geotropic reactions. Sachs has urged as objection to the localization of the motor zone the argument that many of the results pointing to this conclusion have been obtained from abnormal conditions, the foremost of which he assumes as the placing of the root in such position that its tip projects above the horizontal. He assumes that the greatest geotropic stimulation is obtained when the tip is horizontal. This has been disproven by recent investigations, which have demonstrated that geotropic excitation increases in force as the tip approaches the vertical pointing upward.

Sachs urged that the curvature obtained by roots placed in such position underwent minor excitation, in accordance with his theory that the entire growing region is geotropically sensitive as well as motile. The recent confirmation of Darwin's theory of the localization of the irritable cells in the apex of the root renders these objections invalid, since it is the relation of the sensory zone only to the vertical which affects the movement.

If the curvature is distributed according to the rapidity of growth the geotropic curvatures should, according to the theory of Sachs, resemble those obtained by a mechanical curvature of the root, since the normal extensibility of the walls may be assumed to be in direct proportion to the rapidity of elongation. The curves obtained by mechanical bending of roots are not in accordance with those attributed by Sachs to geotropism. The radius of curvature is shortest in the region of most rapid growth and gradually elongates in both directions. In geotropic curvatures, however, the difference between the radii of curvature of the forward portion of the region of rapid growth and the apical and basal portions is abrupt and marked, showing that a special region has effected the greater part of the curvature. In this region the cortical and vascular cells have not attained more than 25 to 35 per cent. of their final length. The minor curvature, which includes the basal and apical portions of the root, may be explained entirely as mechanical results of the disturbance of tensions by the action of the cells of the specialized zone, and, as a matter of fact, are reproduced exactly in mechanical curvatures. At any rate these minor curvatures actually disappear with the fixation of the organ in its new position. In conclusion of this detail, it is to be said that the formation of a sharper break or angle required by Sachs to establish the theory of a localized motor zone is not consequential in a body so plastic as the growing portion of the root.

In connection with the question of localization of curvatures the facts obtained as to the behavior of a root in recurvatures are of value. It has been quite generally asserted and received that if a geotropically excited root were allowed to effect only a small amount of curvature, and then placed in a position which would induce a curvature exactly opposite, the first curve would be obliterated.

I have directed some experiments to this phase of the question in the following manner: Seedlings of Zea were placed in such position that the roots were pointing nearly vertically upward for a period of five hours and a curvature of 50° had ensued. At this time the root was reversed and placed in such position that a curvature would be induced in exactly the opposite direction. This curvature was allowed to proceed for fifteen hours, until it was much more marked than in the first instance. The roots were then killed and hardened in chromic acid in the usual manner. The sections thus obtained show that such curvatures cannot be obliterated (see table XII).

While in most roots the motor zone lies forward of the root hairs, sometimes the hairs may attain considerable length before the curvature is entirely accomplished. In Zea the papilla like extensions were to be seen often in the apical part of the motor zone three hours after excitation, and the tubes had attained a length equal to many times their diameter in curvatures eight hours after excitation. That is to say, the zone of root hairs had moved forward until it embraced the region of curvature before motion had entirely ceased. No difference of structure or form could be made out between those of the convex and concave sides. It is to be seen that the movement would often result in the rupture of the hairs on the region of curvature, especially on the convex side.

In this zone the annular vessels are represented by great cells with a length of 0.75 to 1.^{mm}, and a diameter of 0.2 to 0.3^{mm}. The nuclei are still present and a distinct lining layer. The remaining vascular elements are still in the form of elongated cells in which the protoplasmic content and no differentiation of the wall have appeared. The cortical parenchyma is in the form of short cylindrical cells with the ends in some instances slightly rounded and in others distinctly plane.

X. THE MECHANISM OF CURVATURE.

In the examination of the curvatures of roots in order to determine the forces active in producing curvature I have used specimens of *Zea mais*, *Phaseolus vulgaris*, *Pisum sativum*, *Ari-*

saema triphyllum, and *Phoenix dactylifera.* On account of the fact that Zea has been used in so many researches of this character, and because so many of the minor features are well known, I have taken it through every phase of treatment.

It is universally admitted on all hands that the forces actually productive of curvatures are manifested in the newly formed cortex of the convex side of the root, and the point upon which question is raised is whether the elongation of the cortical cells is due to actual growth of cells or is due to a sudden induced ductility and elasticity of the longitudinal membranes. As will be seen below my results give direct evidence upon this point.

The first direct work upon this point was done by Cieselski (1), who concluded that the changes in the motor zones of curving roots consist chiefly in a greatly exaggerated increase in size in all directions of the cells (of the cortex) of the convex side, and not only a decreased growth of the cells of the concave side, but also a compression of these cells. The cells of the convex side are enlarged in all three axes, and the cells of the concave side in every axis are below the average size, while the walls are wrinkled and folded. Since Cieselski's work has been made the basis of so much recent work which must be corrected in the light of my own results, I quote his paragraph containing this matter in full, and reproduce the figure showing the structure of a curved root.

> Schon die der Untersuchung des Langschnittes einer solchen stark gekrümmten Wurzel fallt es auf, dass die Zellen der Epidermis und des Rindenparenchyms der unteren concaven Kante vielfach gegeneinander verschoben, keilformig zusammengedruckt sind, und nicht selten Falten in den aüsseren Conturen des concaven Bogens erscheinen, während die obere convexe Kante eine gleichmässige Spannung und stark ausgepragte, regelmässige Entwickelung der entsprechenden Zellen zeigt. Das mikroskopische Bild überzeugt uns hiernach mit voller Bestimmtheit, dass die an der convexen Seite gelegenen Zellen eine abnorme Streckung nach allen Richtungen erlitten und dadurch die Zellen der concaven Kante nicht nur an der entsprechenden Vergrösserung gehindert, sondern sogar comprimirt haben, wie dies die vielfachen wir nun die Grosse der Zellen an den beiden Kanten genauer, so finden wir, dass die der convexen nicht blos der Lange nach, sondern auch nach den beiden anderen Dimensionen weit über das normale Mass ausgedehnt haben,

während die Zellen der concaven Kante zusammengedruckt erscheinen und in ihren drei Achsen bei weitem hinter dem Mittel zurückgeblieben sind. Vergl. *fig. 4.* (*Plate XXVIII, M.*)

Aus vielen Messungen, die ich an stark gekrümmten Wurzeln ausgeführt habe, führe ich nur eine beliebige an; die Werthe sind hier das Mittel aus je 5 Messungen, und zwar betreffen diese nur die erste an der Epidermis gelegene Schicht des Rindenparenchyms der beiden Kanten der Krümmungsstelle und dann einer Region weiter unten, wo die Wurzel gerade senkrecht abwärts sich entwickelt hat; es ist noch zu bemerken dass alle Zellen bereits ihr Wachstum vollendet haben.

Die Grosse der Zellen der erwahnten Schicht betrug:

	Lange	Breite	Dicke
an der convexen Kante, - - -	0.125$^{\text{mm}}$	0.045$^{\text{mm}}$	0.042$^{\text{mm}}$
an der concaven Kante, - - - -	0.020$^{\text{mm}}$	0.025$^{\text{mm}}$	0.026$^{\text{mm}}$
bei normaler Ausbildung - - -	0.099$^{\text{mm}}$	0.035$^{\text{mm}}$	0.032$^{\text{mm}}$.

Cieselski's assertions were not fully confirmed by Sachs' work of the following year. Some incomplete observations by Sachs pointed to the conclusion that curvature was accompanied by an accelerated increase of the radial diameter of the cortical cells of the concave side, and a retardation of the radial increase of the cortical cells of the convex side. He says (24, p. 469):

> Einige noch zu vervollständigende Beobachtungen (s. oben) weisen darauf hin, dass die Retardation des Längenwachstums auf der Unterseite mit einer Steigerung, die Beschleunigung des Längenwachstums auf der Oberseite mit einer Beeintrachtigung des Wachstums in radialen Richtung verbunden ist; die Zellen der concaven Seite machen auf den Beobachter den Eindruck als ob sie in der Längsrichtung comprimirt, daher in die Querrichtung erweitert, der die convexen Seite dagegen als waren sie in der Längsrichtung gezerrt und dabei verengert; dabei stehen die Querwände der Zellen der concaven Rinde radial, in der convexen Seite sind schief und prosenchymatisch zugespitzt.

This conclusion is based upon the following measurements. Roots of Vicia were allowed to curve for fourteen hours, and then the distance between marks previously placed upon it were taken by readings with the microscope.

VICIA FABA.

Amount of growth in length	
Convex side, - - - - - -	5.8$^{\text{mm}}$
Concave side, - - - - - -	2.8$^{\text{mm}}$

Median line,	4.3^{mm}
Normal root,	5.5^{mm}
Acceleration of convex side,	0.3^{mm}
Retardation of concave side,	2.7^{mm}
Retardation of middle line,	1.2^{mm}

In a number of measurements of the length of the cells of the cortex of the convex and concave sides Sachs found the convex exceeded the concave in these ratios of 1 : 1.6, 1 : 1.8, 1 : 2, and 1 : 3.4. It was to be said, therefore, that the cortex of the concave side gains in length and breadth at the same time, but at a rate much below the normal. This statement has also been held to apply to all tendrils by Sachs as well as de Vries.

Noll has also paid some attention to the comparative changes in the size and contours of the convex and concave sides of curving shoots (1888) of dicotyledonous and monocotyledonous plants. He has from the beginning of his researches steadily advocated the theory that curvatures were due to an induced increase in the ductility of the membranes of the convex side, and has adduced some very conclusive evidence in his most recent paper on the subject (1895).

In the descriptions of the actual contours of the motile cells in the zone of curvature he confirms Cieselski's view, that the cells of the convex side increase in every diameter so far as stems are concerned. Thus, he says (15, p. 526):

> Wie eine genaue mikroscopische Untersuchung, oft aber auch schon der erste Anblick lehrt, werden die Zellen der Konvexseiten bei der Krümmung nicht nur länger, sondern auch breiter und höher. Wenn auch die Zunahme in der einen Dimensionen doch zuweilen das Doppelte erreichen und übertreffen, wie es besonders bei Grasknoten oft wahrzunehmen ist.

This statement is confirmed by drawings made with a camera lucida, and must therefore be accepted as a fact. However, none of these drawings include sections of roots. A measurement of the drawings shows that in the radial diameter of the epidermal cells of the grass the concave exceeds the convex in the ratio 1.1 to 1, and in the epidermal cells of the Vicia in the ratio 77 : 66. A similar relation is to be seen in some later reproductions (16, pp. 73, 74) of the radial outlines of the epidermis and collenchyma of the curving region of stems of *Vicia Faba*. Cieselski's results were based upon experiments with Zea, Vicia, and *Ervum lens*, and Sachs' results upon Pisum, Phaseolus, Cucurbita, Quercus, Polygonum, Lepidium, Zea, Triticum, Vicia, and Æsculus. So far as I have examined the above mentioned species my conclusions as to the behavior of the cortical cells of the convex side agree with those obtained by Sachs. But in material, such as the roots of Phoenix, presenting different mechanical conditions I have found an action of the convex side similar to that wrongly ascribed to Zea by Cieselski. I am at a loss to account for his mistake in the matter.

XI. SCOPE OF EXPERIMENTS.

In addition to the experimental results adduced in the preceding portions of this paper, chief attention has been paid to the collection of data bearing upon the mechanism of curvature, with reference to the character of the changes ensuing in the motor zone during curvature. To this end a series of experiments was devised by which reaction curvatures were obtained in the following manner: Geotropic curvatures were obtained by placing seedlings in such position that the radicle pointed nearly vertically upward, and the curved portions, inclusive of the apex, were taken, some at three, others at eight, twenty, and seventy hours after the excitation began. The roots were in moist air, sawdust, or earth, at temperatures between 16 and 20° C. Mechanically curved preparations of the motor zone were made as follows: Two pins were driven in a plate of moist cork at a distance apart slightly in excess of the diameter of the apical portion of the root. The root was thrust between these pins in such manner that when the basal portion was moved to one side a curvature would be produced in the motor zone. To accomplish the bending a third pin, placed against the side of the root, was slowly moved laterally until the root was bent at right angles when the pin was thrust in the cork, and the entire preparation immersed in a hardening solution. Some illuminating comparisons were obtained from this material. In order to determine, if possible, the nature of the changes induced in the motor zone previous to reaction, seedlings were placed in such position that the radicles pointed nearly vertically upward. After a time, approximately equal to the latent period of the organ, the motor zone was bent mechanically in the plane in which curvature would have ensued if the roots had been allowed to react normally. The bending and killing was accomplished as above.

Traumatropic curvatures were produced for the study of the motor and sensory zones as follows: The tips of roots were touched with acetic acid or a hot rod, or cut with a razor in the manner described by Spalding (28), and then the seedling was placed in a moist chamber or moist sawdust. Roots which were to be placed in the moist chamber could be branded by means of a glass rod heated in the yellow gas flame. The adhering portion of carbon served to mark the location and direction of the branding. It is to be said that in general traumatropic reactions exhibit a much longer latent period than those of geotropism. In some instances branded roots were placed in such position as to be geotropically excited at the time, although no uniform acceleration of curvature was thus obtained.

So far as the information of the writer is concerned, it does not appear that any attempt has been made to obtain the anatomical details and stature of the cells of the motor zone in a root in which the curvature recently produced has been straightened by an excitation in the opposite direction. No exact data are accessible, but almost all of the writers who have dealt with the subject are unanimous in the agreement that young curvatures may be straightened and equalized. The material bearing upon this point was obtained by placing root tips pointing upward until various angles of geotropic curvature had been formed, and then by a half revolution of the basal portion of the root upon its axis and the proper lateral adjustment, the tip was brought into a position similar to the original with respect to the vertical, but with the excitation tending to induce curvature in the opposite direction. The results obtained from the sections of roots thus treated form by no means the least important part of this paper.

XII. PREPARATION OF SECTIONS.

In the determination of changes in the motor zone it is of the greatest importance to kill and fix the tissues with no disturbance of the existing relations of the membranes, and to cut sections in the plane of curvature through a region embracing the root cap and the region lying between it and the motor zone, and a portion of the root basal to the motor zone. Furthermore, it is highly desirable that the sections made under different conditions should be made permanent and held for comparison. Simple as this matter may seem, it does not appear to have been done by any of my predecessors. The roots were killed, hardened, and fixed in a 1 per cent. solution of chromic acid, in which they were allowed to remain for twenty-four hours. After careful removal from the chromic acid, they were placed in perforated porcelain cylinders, washed for twenty-four hours in running water, then successively transferred through a series of alcohols to 90 per cent., and into a weak solution of Bismarck brown in commercial alcohol. The roots were allowed to remain in the stain two or three days, and were then washed out for twenty-four hours in absolute alcohol, and were transferred through mixtures of alcohol and xylol and paraffin into the paraffin bath at 50° C. Six hours later they were embedded, sections cut on a Minot microtome, fixed to the slide with collodion and clove oil, cleared with turpentine and mounted in Canada balsam in oil of cajeput. This method was found to give most excellent results. The walls were deeply stained, while the protoplasm and nucleus took up the dye only sparingly. The color is especially well adapted to photomicrographic reproduction.

XIII. MEASUREMENTS AND OBSERVATIONS.

Many hundreds of sections were obtained and are still preserved. From the measurements made from them representative tables have been selected and are given below. These tables, together with the notes which follow, were made with a view to determine the changes in form and size of the cells of the convex and concave sides. In tissues of this character it is difficult to make any comparative measurements of the relative thickness of the walls. The figures represent divisions of the eyepiece micrometer and have an actual value of .002857^{mm}.

TABLE I.

Median longitudinal section of root excited geotropically for three hours and curved through an angle of 60°. The quantities are given in the nearest integer.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical							Basal	Average
(Ep)	35	30	20	50	40	42	20	43	35.
(2)	27	54	56	70	95	53	45	..	57.
(3)	54	30	30	50	30	60	..	..	42.
(4)	51	43	48	53	76	54	60	..	56.
(5)	35	35	40	40	30	38	50	30	37.
(6)	33	33	54	95	35	30	60	..	48.
(7)	30	25	30	30	28	32	36	54	33.
(8)	40	40	40	33	35	35	25	..	37.
		Average length of cells, - - - - - -							43·3

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical								Basal	Average
(Ep)	15	15	21	30	20	35	15	28	20	22.
(2)	22	30	18	23	27	30	25	30	23	25.
(3)	28	50	42	40	30	22	40	51	55	40.
(4)	20	25	46	43	40	30	20	45	50	38.
(5)	32	33	26	58	40	50	30	24	25	35.
(6)	18	28	28	30	40	30	20	25	20	28.
(7)	28	30	22	25	32	43	40	32	45	32.
(8)	15	25	15	18	10	35	15	20	22	19.
		Average length of cells, - - - - - -								29·9

TABLE II.

Tangential longitudinal section of root geotropically excited for three hours and curved through 60°. The section lay entirely within the newly formed cortex.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical							Basal		Average
(Ep)	25	23	25	45	40	25	35	46	55	35.54
(2)	30	40	50	45	55	58	60	..	..	48.3
(3)	30	50	62	60	40	37	35	..	..	45.
(4)	30	30	33	65	40	30	40	40	..	38.5
(5)	40	45	44	40	45	45	50	50	..	44.87
(6)	33	40	20	20	25	26	30	40	..	26.75
(7)	25	45	40	23	30	50	65	30	..	39.12
(8)	45	25	28	32	25	30	30	40	45	34.45
(9)	21	25	35	32	34	33	23	20	20	27.
(10)	22	22	26	30	26	30	28	30	26	26.66
(11)	30	36	16	20	22	25	23	42	38	28.
(12)	36	40	38	30	34	36	38	40	40	35.77
(13)	20	16	22	15	15	28	30	30	..	22.
(14)	20	15	20	40	36	34	34	32	..	16.37
(15)	18	30	28	22	34	34	32	34	..	29.

MEDIAN.

Apical							Basal		Average
25	25	20	25	24	32	28	30	..	26.2

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical							Basal		Average
(15)	25	25	30	30	35	36	38	32	..	31.37
(14)	25	21	26	20	30	26	36	35	..	26.66
(13)	..	28	30	30	31	30	26	36	28	29.87
(12)	20	10	20	11	30	10	20	35	43	21.11
(11)	35	40	30	20	30	30	20	37	37	31.
(10)	16	20	20	30	30	31	30	25	21	24.77
(9)	15	15	16	40	40	25	20	22	40	28.11
(8)	28	22	22	28	32	40	40	22	22	27.33
(7)	28	25	18	18	20	20	35	25	20	23.33
(6)	30	35	20	18	20	22	21	22	..	20.75
(5)	28	30	36	25	30	34	30	30	..	29.75
(4)	20	20	20	26	26	28	40	36	..	27.
(3)	..	..	..	..	..	..	..	..		
(2)	..	..	..	..	..	..	..	..		
(Ep)	..	..	..	..	..	..	..	..		

Average length of cells of convex side, - - - 35.45

Average length of cells of concave side, - - - 29.18

TABLE III.

Median longitudinal section of root of Zea excited geotropically three hours and curved through 60°.

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical								Basal	Average
(Ep)	12	13	14	12	12	12	13	10	10	12.
(2)	6	6	7	9	8	8	7	10	7	7.5
(3)	7	7	5	8	7	7	4	4	5	6.
(4)	7	5	6	7	11	5	9	6	8	7.
(5)	7	7	4	3	5	7	5	5	8	7.
(6)	7	7	5	4	6	6	5	7	9	6.
(7)	10	11	9	6	8	5	8	10	10	8.5
(8)	5	8	9	5	7	6	8	5	6	6.5
		Average width of cells,		-	-	-	-	-	-	7.56

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical								Basal	Average
(Ep)	12	11	12	11	10	11	11	11	..	11.
(2)	8	9	6	7	8	12	12	12	..	9.
(3)	7	8	8	9	10	9	5	5	..	9.5
(4)	7	6	5	7	4	9	10	7	..	7.
(5)	5	5	4	3	4	8	8	8	..	5.5
(6)	6	7	8	8	7	6	7	8	..	7.
(7)	10	10	9	9	9	10	8	7	..	9.
(8)	8	8	9	10	9	8	8	10	..	9.
		Average width of cells,		-	-	-	-	-	-	8.25

TABLE IV.

Table showing comparisons of average lengths of cells of convex and concave sides of root of *Zea mais*, geotropically excited for three hours and curved through 60°. The rows of cells are numbered from the epidermis toward the center of the root.

MEDIAN LONGITUDINAL SECTION.

	Ep	2	3	4	5	6	7	8	9	10
Convex	35	57	42	56	37	48	33	37	..	..
Concave	22	25	40	38	35	28	32	19	..	..

TANGENTIAL LONGITUDINAL SECTION.

	Ep	2	3	4	5	6	7	8	9	10
Convex	36	48	45	38.5	44.8	26.7	39	34	27	26.6
Concave	..	..	..	27	29.7	20.7	23	27	28	24

An examination of the sections from which the above measurements were made reveals the fact that the distance from the apex of the growing point to the cross section exhibiting the shortest radius of curvature is 2^{mm}; from the apex to the beginning of the region of curvature 1.5^{mm}. At this point the root is 1^{mm} in diameter. The epidermal cells of the concave side appear densely granular. The greater number of the nuclei in the cortex of the concave side appear to lie on the peripheral side of the cells, though not always substantiated by actual count. The axial diameter of the cortical cells is smaller than that of the convex side, though no great compression has been exerted in this plane, since no foldings were observable in the longitudinal walls. The radial cross walls were of a contour indicative of compression in an axial direction and exhibited a wavy or undulating outline (*fig. 5*).

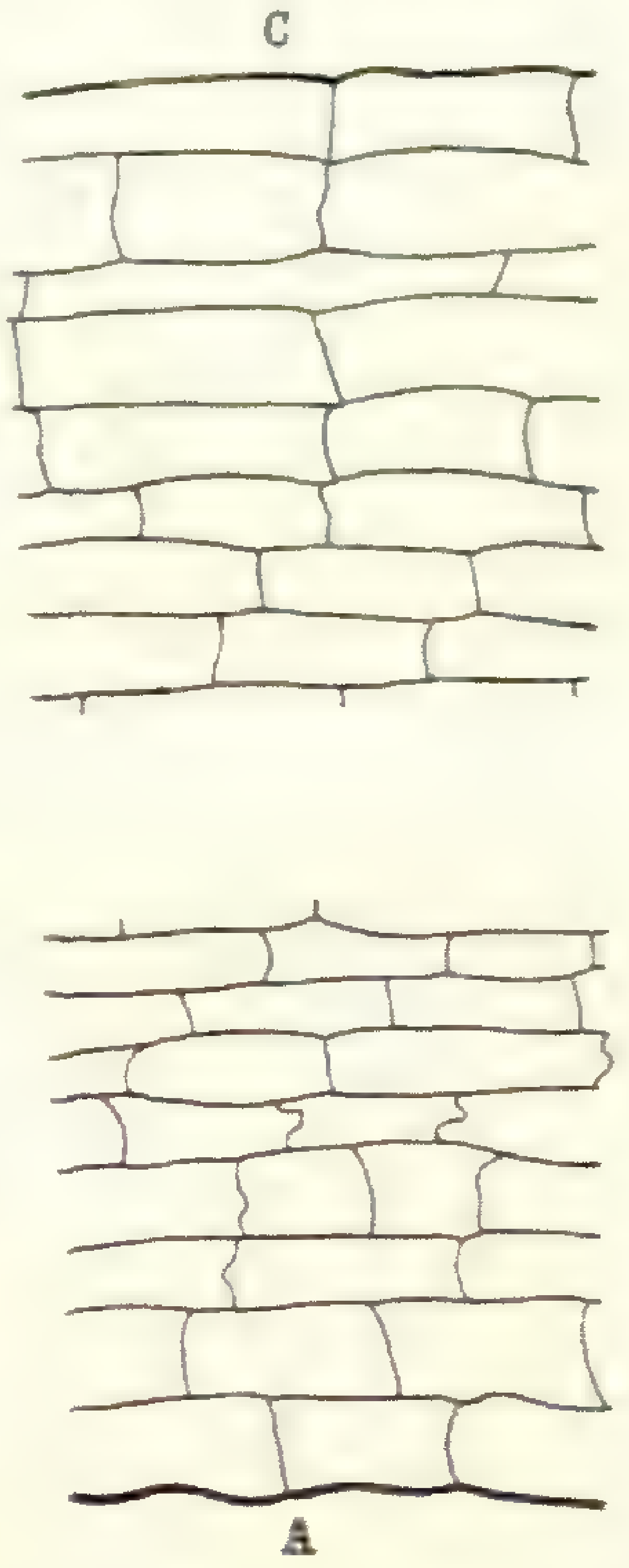

FIG. 5. Longitudinal sections through curved portion of a root of Zea three hours after excitation. *C*, convex side; *A*, concave side (see tables I–IV).

TABLE V.

Median longitudinal section of root of *Zea mais* twenty hours after excitation began, and after a curvature of 105° had been effected.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical							Basal		Average
(Ep)	90	40	50	60	120	55	..	..	..	69.2
(2)	70	40	60	55	90	125	..	..	..	73.3

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE—*cont'd.*

	Apical								Basal	Average
(3)	35	30	40	48	55	52	40	..	..	42.9
(4)	38	38	30	60	80	70	50	..	..	52.3
(5)	55	33	42	70	50	45	..	..	..	49.2
(6)	48	30	30	40	40	35	..	..	..	37.2
(7)	30	32	32	33	23	45	25	..	..	31.4
(8)	23	20	25	35	30	35	34	..	..	28.9
	Average length of cells, - - - - - -									48.05

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical									Basal	Average
(Ep)	23	20	20	30	18	30	15	20	10	10	19.6
(2)	14	22	20	20	30	16	20	12	10	25	18.9
(3)	20	20	26	35	23	38	35	30	25	37	29.3
(4)	..	..	23	30	32	35	31	30	30	40	28.8
(5)	..	..	..	..	..	23	18	20	20	15	19.2
(6)	35	30	28	27	20	20	23	18	..	..	25.2
(7)	34	37	30	35	28	31	30	31	..	..	31.9
	Average length of cells, - - - - - -										24.7

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical							Basal	Average
(Ep)	9	9	9	8	10	9	10	10	9.25
(2)	8	8	5	5	8	8	7	7	8.25
(3)	7	6	6	6	8	8	7	5	6.62
(4)	5	5	4	5	7	8	11	11	7.
(5)	10	10	10	11	14	12	12	10	11.1
(6)	19	14	19	15	14	14	15	16	15.75
(7)	20	22	23	22	20	21	22	..	21.43
	Average width of cells, - - - - - -								11.4

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical							Basal		Average
(Ep)	8	8	5	6	5	3	5	3	5	5.77
(2)	6	8	8	7	7	8	7	7	7	7.22
(3)	5	5	3	5	4	5	5	5	5	4.66
(4)	5	6	6	6	8	6	6	8	7	6.44
(5)	10	9	9	6	6	4	5	7	7	7.22
(6)	5	4	5	4	6	4	5	9	7	5.44
(7)	9	10	11	10	10	10	10	10	9	9.98
(8)	10	9	10	7	10	9	9	8	10	9.11
	Average width of cells, - - - - - -									6.98

TABLE VI.

Comparison of measurements of rows of cells in median longitudinal section of root of Zea excited geotropically for twenty hours and curved through 105°.

MEASUREMENTS OF LENGTH.

	Ep. 1	2	3	4	5	6	7	Average
Concave	19.6	18.9	29.3	28.8	19.2	25.2	31.9	24.7
Convex	69.2	73.3	42.9	52.3	49.2	37.2	31.4	48.05

MEASUREMENTS OF WIDTH.

	Ep. 1	2	3	4	5	6	7	Average
Concave	9.25	8.25	6.62	7.	11.1	15.7	21.4	11.4
Convex	5.77	7.22	4.66	6.4	7.2	5.4	9.8	6.98

An examination of the sections of which measurements are given in tables V and VI shows that the distance from the apex of the growing point to the cross section having the shortest radius of curvature is 2.24^{mm}, and the width of the motor zone at its forward edge is 1.12^{mm}. The length of the cells from which the annular vessels will be formed is about two-thirds of that of these cells in a region at a distance of 1.5^{mm} in a basal direction from the region of greatest curvature.

The granular density of the protoplasm of the epidermal cells of the concave side is less marked than in younger curvatures, and the external walls are thickened two to four times their former diameter. Root hairs are abundant on the regions both apical and basal to the region of greatest curvature, but are also wholly absent from the region exhibiting the shortest radius of curvature, when the walls are most thickened. The sub-epidermal cells are rectangular in outline, with the end walls slightly oblique and exhibiting undulating foldings. The rows of cells in the fourth to the eighth layers have taken a contour indicative of axial compression. The axial walls bulge in a radial direction, and the radial walls are folded more sharply than those of the layers near the epidermis, or in the same region in younger curvatures. The difference in the granular densities of the cortical regions of the convex and concave sides has nearly disappeared. However, the membranes of the entire concave side have become much heavier. The epidermal cells of the convex side, as well as the underlying two or three layers, have evidently undergone passive stretching. The longitudinal walls have been brought closer together, and in some instances the appearance of collapse is present. The end walls of the epidermal cells are distorted obliquely, but on account of their greater thickness do not exhibit the sharp foldings of the subepidermal layers. The inner layers of the cortical region have rounded turgid outlines, and the curves of the walls are wavy in outline, indicating that these cells have been most active in producing the elongation of this side of the organ. Intercellular spaces are larger and more abundant than in the concave side.

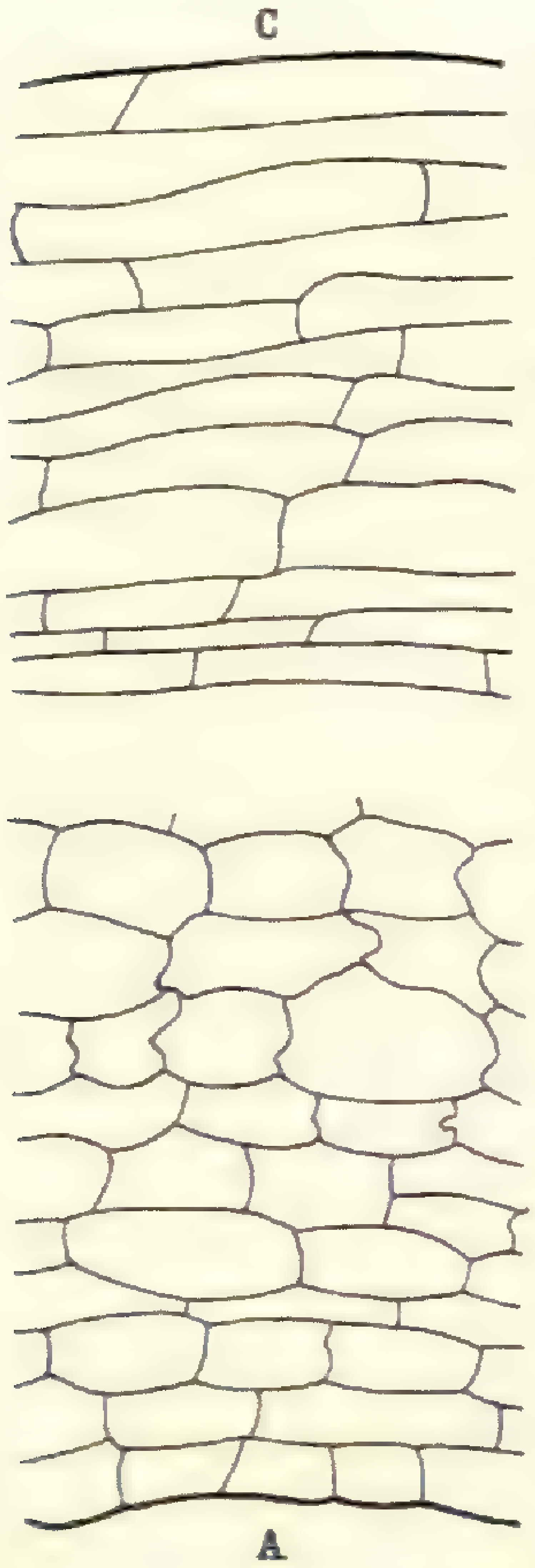

Fig. 6. Longitudinal sections through curved portions of root of Zea twenty hours after the beginning of excitation. *C*, convex side, *A*, concave side (see tables V–VI).

The apical portion of the root, 1.2^{mm} in length, has become quite straight, and the tip no longer exhibits traces of the strain exerted upon it by the curving forces when the motion began. The forward limit of the region of curvature is quite sharply marked (*fig. 6*).

TABLE VII.

Median longitudinal section of *Zea mais*, placed vertically upright and curved through 160°. The measurements were made in that portion of the root in which the first geotropic excitation occurred, and this part of the curvature was seventy hours old, and exhibits an angle of 90°.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical								Basal	Average
(Ep)	50	55	60	42	30	20	35	40	45	53.1
(2)	100	40	75	75	115	110	..	..	..	64.38
(3)	70	90	80	120	145	85	110	140	..	105.
(4)	70	70	80	140	110	100	70	100	..	92.5
(5)	110	80	90	50	150	80	90	60	..	88.88
(6)	100	120	45	80	60	110	..	..	..	92.5
(7)	70	70	80	70	70	80	..	..	..	73.3
(8)	65	50	70	80	45	50	..	..	..	60.
	Average length of cells									78.75

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

(Ep)	23	22	16	22	16	28	16	..	..	20.4
(2)	43	40	42	40	40	38	40	..	..	40.55
(3)	40	40	65	50	52	48	65	..	..	51.4
(4)	34	34	30	40	40	47	51	..	..	39.7
(5)	32	30	30	51	45	40	50	..	..	39.7
(6)	32	30	45	46	47	35	45	..	..	40.
(7)	38	30	30	45	40	35	35	..	..	36.1
(8)	36	30	20	32	52	41	32	..	..	34.7
	Average width of cells,									25.28

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical								Basal	Average
(Ep)	11	10	12	11	13	10	11	11	11	11.1
(2)	6	11	7	8	10	10	11	9	11	9.2
(3)	5	8	9	6	5	15	13	13	10	8.2
(4)	11	10	15	11	11	11	10	8	9	10.6
(5)	10	18	15	15	15	14	12	11	18	14.2
(6)	14	14	12	11	15	16	18	18	20	15.3
(7)	20	15	20	14	14	15	20	18	12	16.4
(8)	18	18	15	16	13	12	15	16	14	15.2
	Average width of cells,									12.52

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

(Ep)	9	8	11	8	8	9	8	9	7	8.55
(2)	10	11	9	11	10	8	7	8	9	9.22
(3)	9	9	8	7	7	9	7	6	7	7.77
(4)	7	9	8	6	8	7	7	5	7	7.11
(5)	8	10	10	10	9	15	14	15	15	11.77
(6)	16	10	8	10	10	13	12	14	11	11.
(7)	12	11	9	10	11	14	14	17	16	12.66
(8)	10	11	10	10	14	14	12	15	15	12.33
	Average width of cells,									10.05

The width of the sections from which above measurements were taken is 1.12^{mm}; the width of the cortex (including the epidermis) of the concave side is .4^{mm}, and of a similar region on the convex side .3^{mm}. The mechanics of cells are to be compared with the data given in tables I to V, since the amount of curvature is not much greater. The differences are to be ascribed to changes brought about by growth subsequent to curvature.

The epidermal and sub-epidermal cells of the concave side are more densely granular than those of the convex side. The emergences from the epidermal system are very few, and the walls of all of the cells show a thickening noticeably greater than those of the convex side. The foldings of the end walls seen in the sections described in the preceding tables are not to be found here. On the other, the end walls of the cells of the convex side exhibit more sharply folded bends than those described in tables V–VII. The epidermal cells exhibit a normal number of emergences, as well as the flanks of the organ. The epidermal and sub-epidermal walls do not show the evidences of the tensions to be seen in younger curvatures, and the suggestion arises that these tensions may have been in part relieved by growth subsequent to curvature. This growth would follow, of course, the laws governing growth under tensions, by which the first accession of strains would retard elongation, to be followed later by an accelerated elongation, which would obliterate evidences of tension.

TABLE VIII.

Median longitudinal section of root of *Zea mais* geotropically excited and curved through 90°. Portion of root containing curvature killed after tip had reached a distance of 3^{cm} from the cross section having the shortest radius of curvature.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical					Basal	Average
(Ep)	..	..	..	..	..	..	.. ..
(2)	90	65	45	130	100	100	88.3

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE—*cont'd.*

	Apical					Basal	Average
(3)	100	80	90	125	110	90	97.5
(4)	80	85	85	95	75	80	83.3
(5)	54	42	52	50	50	45	48.8
(6)	60	65	65	70	55	70	64.1
(7)	54	60	65	75	80	75	68.1
(8)	60	80	50	60	65	75	65.
(9)	65	45	60	65	70	60	68.
	Average length of cells,		-	-	-	-	71.99

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical								Basal	Average
(Ep)	..	..	..	..	..	..	..	..	..	
(2)	..	..	..	..	..	..	..	..	..	
(3)	50	28	30	52	42	50	45	55	..	44
(4)	25	15	20	32	30	50	30	50	..	31.5
(5)	45	20	35	25	30	40	50	25	..	33.75
(6)	30	40	25	52	52	40	45	..	..	38.62
(7)	30	45	35	32	42	50	52	..	..	40.85
(8)	30	45	30	35	45	50	60	..	..	42.14
(9)	50	45	52	40	48	35	30	..	..	43.57
		Average length of cells, -		-	-	-	-	-	-	45.

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical							Basal	Average
(Ep)	..	..	..	..	..	..	..	..	.. ..
(2)	..	..	..	..	..	..	..	..	.. ..
(3)	..	..	..	..	..	..	..	..	.. ..
(4)	9	7	6	8	8	8	6	5	7.12
(5)	7	7	6	9	6	6	8	7	7
(6)	7	6	6	7	7	8	8	8	7.12
(7)	8	8	9	7	9	11	7	9	8.5
(8)	7	7	9	7	8	8	10	7	7.89
(9)	9	9	8	8	7	9	7	9	8.25
(10)	10	10	11	10	9	10	11	12	10.43
(11)	11	12	13	13	13	12	11	..	12
	Average width of cells,			-	-	-	-	-	8.53

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical							Basal	Average
(Ep)	..	..	..	..	..	..	..	..	.. ..
(2)	..	..	..	..	.	..	..	..	.. ..

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE—*cont'd.*

	Apical							Basal	Average
(3)	..	..	..	..	..	..	..	..	....
(4)	8	6	7	6	7	7	6	..	6.71
(5)	8	7	8	8	7	6	7	..	7.42
(6)	12	11	11	11	11	12	13	..	11.57
(7)	15	15	15	15	15	12	13	..	14.28
(8)	17	16	15	15	15	15	16	..	15.57
(9)	14	15	11	10	11	12	10	..	11.82
(10)	15	15	15	15	15	11	16	..	14.57
		Average width of cells,			-	-	-	-	11.69

The curvatures from which the above table was made are comparable to those described under tables I–IV. The angle of curvature is approximately the same, and growth for one hundred hours following the curvature has ensued. After the lapse of this period, the entire surface of the curved portion is free from root hairs. In addition to the disintegration of the walls of the root hairs, the external cells of the root have died. In the sections examined the epidermal and two underlying layers of the concave side, and the epidermal and one layer on the convex side have collapsed. The total width of the section is 1.04^{mm}, of the cortical region of the concave side $.342^{mm}$, of the convex side $.24^{mm}$, and of the central cylinder $.458^{mm}$. The foldings of the end walls of the cells of the concave side have almost disappeared, and present a gently undulating outline, while those of the convex side are pronounced, exhibiting U or V outlines. In all of the curvatures of this stage of development initial layers of secondary roots were to be found on the convex side of the cylinder only. In the above section the rudimentary root had pierced two or three layers of the cortical cells. This is in accordance with the facts described by Noll, in which secondary roots were found to spring from the convex side of curving radicles only. While the initial cause of such an arrangement is not apparent, it is very easily seen that the formation of branches on the concave side of the organ would not only entail the expenditure of many times as much energy in piercing the compressed cortex, but the tensile strength of the curved portion would be decreased. This latter effect is absent from an arrangement of the branches on the convex side, and the fixative power of the system is increased.

TABLE IX.

Median longitudinal section of root of *Zea mais* bent mechanically through 90 .

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical						Basal	Average
(Ep)	54	35	50	40	..	85	90	50.5
(2)	90	90	85	120	100	165	110	95.
(3)	125	75	95	100	130	65	65	93.5
(4)	60	100	55	75	70	70	80	73.
(5)	60	90	100	80	60	80	80	79.3
(6)	60	75	45	80	60	95	85	71.3
(7)	45	55	80	60	70	60	90	65.5
(8)	65	55	60	70	60	70	50	61.4
	Average length of cells,			-	-	-	-	73.56

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical					Basal	Average
(Ep)	55	45	45	20	60	50	45.8
(2)	60	60	65	30	100	45	60
(3)	60	75	28	50	26	70	51.5
(4)	..	..	75	75	50	65	66.4
(5)	70	50	75	50	65	70	64.2
(6)	65	65	70	55	95	..	52.5
(7)	75	60	63	54	80	50	63.7
(8)	50	50	50	60	50	50	50.7
	Average length of cells,			-	-	-	56.85

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical							Basal	Average
(Ep)	7	6	7	..	5	6	6	7	6.5
(2)	7	7	7	7	11	9	7	8	8.
(3)	4	7	8	9	5	5	5	5	6.
(4)	7	6	8	8	7	6	7	5	6.5
(5)	6	6	7	7	6	8	8	8	7.
(6)	6	7	6	6	7	8	6	9	6.87
(7)	8	8	10	9	7	8	7	..	8.14
(8)	5	6	7	9	7	7	..	..	6.83
	Average width of cells,				-	-	-	-	6.98

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical							Basal	Average
(Ep)	8	7	8	6	5	7	7	8	7.
(2)	9	9	9	10	9	10	10	9	9.375
(3)	9	8	6	8	6	6	11	10	8.
(4)	10	9	8	8	9	7	9	9	8.62
(5)	7	8	8	8	9	11	10	..	8.71
(6)	9	8	8	8	7	8	10	11	8.62
Average width of cells,					-	-	-	-	8.4

The root treated in the above manner offers a sequel to Noll's bending experiments, by which the ductility of the walls of the concave side of the stems was found to be diminished, or less than the normal. The region of curvature artificially produced coincided with that of geotropically excited roots, but it extended over the entire growing region of the tip in such manner that the extreme apical portion was bent only by the strains exerted upon it by the curvature artificially produced in the growing region. This fact disposes of the theory of Sachs that the entire apical portion is active in curvature. The region of shortest curvature in all of these experiments was found to be about 2^{mm} from the tip of the apical region, and the curvature decreased quite gradually apically and basally, as is asserted of the root in geotropic curvatures by Sachs. The form of such curvatures is undoubtedly due to the distribution of ductility in the different portions of the organ and the resultant curve approaches a hyperbola. In geotropic curvature the greatest bending occurs within very narrow limits in such manner as to favor the assumption that an increase in the ductility of the membranes has taken place here.

The cortical region of the convex side has a width of .24^{mm}, and of the concave side .25^{mm}, the central cylinder .4^{mm}.

The measurements given above show that actual enlargement of the superficial content of the cells of the convex side, and a diminution of those of the concave side has taken place, yet there is no apparent difference in the density of protoplasmic contents. The cells of the concave side exhibit plainly marked evidence of the compression which has been exerted upon them.

Some are thrown from a position parallel to the longitudinal axis of the root and the end walls exhibited foldings, shallow and V shaped, but in no place do these elements exhibit the contours to be seen in curvatures of 90° produced by geotropic excitation, where the radial and longitudinal axes were often equal. The epidermal cells of the convex side were torn and collapsed in places. The longitudinal walls of all cells on this side were thrown outward and inward from their natural positions. The end walls were sharply and deeply folded and pouched.

The greater distortion of the cross walls on both sides of the organ is to be attributed in part to the fact that these membranes are quite newly formed and have not acquired a rigidity which enables them to withstand columnar strains of any amount. With the growth of the cortex of the concave side in thickness, the foldings in these walls are taken up in part or almost wholly in slight curvatures.

TABLE X.

Median longitudinal section of root of *Zea mais* geotropically excited for one hour, and then mechanically in the plane of would be curvature through 90°.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical						Basal		Average
(Ep)	48	40	35	85	35	40	40	38	45.75
(2)	30	75	42	40	20	30	80	120	50.9
(3)	45	40	40	50	50	80	50	80	54.4
(4)	75	70	35	42	45	45	30	40	47.75
(5)	55	40	20	50	45	30	30	50	40.
(6)	50	21	23	25	40	42	40	58	37.38
(7)	42	32	36	30	35	45	40	40	37.5
(8)	40	40	30	45	50	42	45	55	43.37
	Average length of cells,				-	-	-	- -	44.63

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical.						Basal		Average
(Ep)	14	25	14	20	20	80	20	50	17.25
(2)	30	21	20	35	50	54	48	45	37.87
(3)	30	22	24	42	20	20	36	52	30.75
(4)	18	20	20	20	42	22	30	18	23.75

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE—*cont'd.*

	Apical							Basal	Average
(5)	28	28	25	22	22	26	30	18	23.62
(6)	28	25	25	30	30	28	20	20	25.75
(7)	20	20	23	31	30	30	35	40	28.62
(8)	28	22	40	20	28	35	33	36	30.25
(9)	20	20	28	38	22	30	20	20	24.75
Average length of cells,				-	-	-	-	-	30.32

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical									Basal	Average
(Ep)	7	8	8	6	6	6	6	6	6	5	6	6.36
(2)	5	4	5	4	4	4	4	5	5	5	5	5.55
(3)	5	5	5	..	4	..	..	..	..	..	..	4.75
(4)	7	7	8	..	10	9	7	8	9	7	5	8.
(5)	12	10	10	..	10	10	10	9	11	9	..	10.1
(6)	8	9	9	..	10	10	10	11	10	9	..	9.66
(7)	10	13	12	11	10	10	10	10	10	10	..	10.6
(8)	8	9	8	..	8	7	8	9	9	..	..	8.25
Average width of cells,					-	-	-	-	-	-	7.91

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical								Basal	Average
(Ep)	11	10	11	10	8	8	10	..	..	9.7
(2)	10	10	11	13	14	7	8	8	..	10.1
(3)	7	7	5	..	6	8	8	9	..	7.1
(4)	7	9	9	7	7	8	8	9	..	8.
(5)	7	8	8	8	8	10	9	10	10	8.66
(6)	6	8	7	11	12	12	12	13	..	10.1
(7)	12	11	12	6	8	9	9	..	..	9.55
(8)	12	12	12	11	12	11	10	11	10	11.22
Average width of cells,				-	-	-	-	-	9.3

The total width of the section in the region of curvature is about $.82^{mm}$, of the convex cortical region $.22^{mm}$, and of the concave cortical region $.2^{mm}$. The walls of the epidermal cells of the concave side are wavy and folded, showing the end pressure exerted against them. The cortex of the concave side exhibits numerous foldings on both longitudinal and end walls, much greater than in the cells mechanically bent without previous excitation. The epidermal and three (in some places four) sub-epidermal layers are torn and collapsed, and the cortex shows the ordinary foldings of the end walls much more marked than those of the mechanically bent organ. On the whole, the curvature of the organs geotropically excited is not distributed over so great a region as in those bent mechanically from a normal condition. This might of course be due to a smaller coefficient of turgidity, and the recurrence of this relation through all of my experiments leads to the suggestion that some alteration must have taken place in the membranes to permit the localization of the curvature. Furthermore, it is impossible to account for the excessive folding and wrinkling of the walls of the cells of the concave side, with decrease of the resistance of the membranes of the convex side, as due to stretching. This decrease would allow a greater part of the bending force to act as a compression upon the cortex of the concave side.

TABLE XI.

Median longitudinal section of normal root. The measurements included a region beginning at a distance of 2^{mm} from the tip of the growing point and of the same age and stage of development as the curved portion of the root described under table V.

MEASUREMENTS OF LENGTH OF CELLS OF SIDE A.

	Apical								Basal	Average
(Ep)	7	8	7	11	7	8	7	10	10	9.37
(2)	16	12	12	10	21	20	12	12	30	16.
(3)	12	11	16	10	14	15	11	21	16	15.75
(4)	21	11	20	11	14	14	10	12	15	16.
(5)	12	11	18	10	12	10	12	18	16	14.88
(6)	15	16	16	16	12	18	18	17	16	16.75
(7)	10	10	16	20	16	15	15	10	10	15.25
(8)	11	12	18	10	11	17	18	10	10	14.62
		Average length of cells, - - - - - -								14.82

MEASUREMENTS OF LENGTH OF CELLS OF SIDE B.

	Apical							Basal	Average
(Ep)	10	7	8	6	6	11	6	6	7.5
(2)	11	10	9	18	14	25	12	15	15.12
(3)	10	8	10	9	12	21	7	8	10.62
(4)	10	11	14	12	10	12	10	10	11.12

MEASUREMENTS OF LENGTH OF CELLS OF SIDE B—*cont'd.*

	Apical							Basal	Average
(5)	10	7	12	21	13	12	11	11	12.12
(6)	11	10	12	11	14	12	11	14	11.88
(7)	9	10	11	12	13	14	10	12	11.25
(8)	10	10	11	12	13	10	13	12	11.25
	Average length of cells,			-	-	-	-	-	11.35

MEASUREMENTS OF WIDTH OF CELLS OF SIDE A.

	Apical							Basal	Average
(Ep)	10	10	10	10	9	9	9	10	9.6
(2)	7	8	8	8	7	7	7	8	7.5
(3)	7	7	7	5	5	6	5	5	5.87
(4)	7	7	6	6	7	6	6	5	6.25
(5)	10	10	10	10	10	10	12	11	10.37
(6)	10	10	10	10	10	11	10	10	10.12
(7)	9	10	8	7	6	7	7	8	7.75
(8)	10	9	8	9	9	9	8	9	8.87
	Average width of cells,			-	-	-	-	-	8.29

MEASUREMENTS OF WIDTH OF CELLS OF SIDE B.

	Apical							Basal	Average
(Ep)	10	8	8	8	9	11	11	11	9.5
(2)	8	8	9	9	8	9	9	9	8.62
(3)	6	7	7	7	7	8	8	9	7.37
(4)	8	9	9	10	10	6	7	8	8.25
(5)	10	7	8	6	9	10	9	8	8.37
(6)	7	8	7	9	9	8	8	10	7.37
(7)	6	7	6	5	5	6	5	5	5.62
(8)	9	9	10	9	10	10	9	8	9.25
	Average width of cells,			-	-	-	-	-	8.047

Measurements of the cells, to obtain the normal stature of the cells of the root for comparison with those of the convex and concave sides, were made by Cieselski upon the portion apical to the curvature (see quotation on p. 328.)

By this method, the average length of the normal cells was found to be .099^{mm}, of cells of the concave side .02^{mm}, of cells of the convex side .125^{mm}. These figures were obtained from roots in which the curvature had been left some distance behind by the growing point, and the original proportions between the length of the cells of the normal and curved portions had been distributed by the subsequent growth, which is of course modified by the tension set up by curvature. Sachs raised the objection that Cieselski's method concealed the true relations of the length of the cells of the convex side to the normal, and that the excessive growth of the former was not apparent. In an effort to evade this error, Sachs compared the length of the cells of the curved portion with averages attained from the measurement of from twenty to forty cells in regions apically and basally to the curvature.

According to his own account, the apical portion of the root was allowed to obtain a length of 2 to 3^{cm}, and the basal portion had made its full growth. He deemed it desirable to allow the curved portion to make the sharpest angle possible, and to reach a great thickness. It is evident that his results do not show the relative stature of the cells of the two sides at the time of curvature, since the subsequent growth processes have intervened. His figures are therefore strictly comparable to those given by myself in table VIII, made from curvatures three to five days old. Sachs found that the average length of cells of the root of *Vicia Faba*, apical and basal to curvatures, was 40 to 44 respectively, with a general average of 42. The length of cells of the convex side was 41, and of the concave side 26.3. In a second example the lengths of the apical and basal portions were found to be 23.2 and 26.2, with an average of 24.6. The average length of cells of the convex side was 28.3, and of the concave side 15. In a root of *Æsculus Hippocastanum* the average lengths of the apical and basal portions were found to be 16 and 23, that of the cells of the convex side 27, and of the concave side 13.3. In a second example of this species the lengths of the cells of the apical and basal portions were found to be 19 and 21.2, with an average of 20.1. The average length of cells of the convex side was 28.1, and of the concave side 9.3. The figures given by Sachs represent divisions of the micrometer of a value of $.005^{mm}$.

The fact that the average length of the cells of the convex side was found to be less than that of the average length of the normal cells in many examples beside those quoted led Sachs to the conclusion that the discrepancy was due to faults in observation. The fault is in the system of obtaining the measurements, however. If only the same factors were operative in the production of curvature that are to be found in normally elongated roots, this method of obtaining the average stature of the normal cells would be allowable. This is not the case, however, as the curvature is produced by an excessive elongation of the convex side, which might be due to growth or ductile stretching, but in either case would be followed by after effects that would destroy the normal relations. Even if this system of measurements were applied to forming or newly formed curvatures, the rapidly increasing and unequal rate of growth of the motor zone would destroy the proportions of the average. A glance at the tables given above shows that the increase in the length of the cells in the basal direction is by no means uniform.

In order to obtain the stature of normal cells in my own observations the measurements were made upon a region corresponding in distance from the apex and stage of development with the curvatures with which comparison was to be made. This region, from which the data in table XI were obtained, corresponds to the region of curvature of the root curved through 105° (see table V). Identical methods of preparation were used and the cells measured from a radial longitudinal plane eight cells in length and eight cells in width radially.

In a comparison of the data obtained from the normal root with the figures of a root curved through 105° after twenty hours of geotropic excitation (table V), the following facts are to be noted. The average lengths of the cells of the normal root are 11.35 and 14.82. The average length of the cells of the concave side in the root bent at an angle of 105° after twenty hours' excitation is 24.7, and of the convex side is 48. If it is supposed that the error has been made in measuring the region in the normal root nearer the tip than in the curved root, the lengths of the cells in the curvature of a root three hours after excitation (concave 29, convex 43) show that in Zea an elongation of both sides of the root takes place during curvature. It is apparent, however, that the epidermal and sub-epidermal cells, which have been in a state of passive tension previous to curvature, will show purely mechanical changes. These mechanical changes will depend upon the angle and rapidity of curvature as well as upon the thickness of the root. It is possible that the passively stretched tension of the epidermal cells in young roots may be converted into a compressed tension in older organs.

A comparison of the radial diameters of the cells of the two sides exhibits changes of a similar nature. The radial diameters of the cells of the convex sides of roots steadily decrease in Zea as the angle of curvature increases, while the reverse is true of the concave side. The decrease is most marked in the peripheral layers of the convex side, and the cortical layers of the concave side in Zea. The radial diameter of the convex side in table III is 7.56, in table VI 6.98. The average diameter of the cells of the concave side in table I is 8.25, in table VI is 11.4.

It seems well demonstrated that the extension in the length of the cells of the convex side of the root of Zea is accompanied by a decrease in radial diameter, and that the slight elongation of the cells of the concave side is attended by an increase in radial diameter. Such conditions lead to the conclusion that the elongation of the convex side is a ductile extension of the longitudinal walls. The ductile extension is accompanied by the usual amount of growth. The longitudinal compression of the cells of the concave side permits only a minimum of growth in this direction and facilitates extension in a radial direction.

TABLE XII.

Median longitudinal section of root of *Zea mais*, allowed to curve geotropically six hours and then reversed five hours. The measurements are taken from the portion of the old curvature, which had decreased from 40° to 15°. The new curvature was formed at a distance of 2^{mm} apical from the first curvature.

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical						Basal		Average
(Ep)	80	70	60	30	50	60	..	..	56.6
(2)	100	80	90	46	30	90	..	..	72.6
(3)	50	50	70	35	45	60	..	..	51.6
(4)	70	35	40	50	50	50	..	..	46.1
(5)	70	60	30	60	50	50	..	..	53.3
			Average length of cells,	-	-	-	-	-	56.04

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical					Basal		Average
(Ep)	50	70	100	70	90	..	..	76.
(2)	60	60	40	45	60	..	..	53.
(3)	60	55	50	48	50	..	..	52.6
(4)	70	45	44	32	35	..	..	48.4
(5)	60	50	90	40	35	..	..	55.
(6)	50	55	65	65	34	..	..	53.8
			Average length of cells,	-	-	-	-	57.7

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical						Basal		Average
(Ep)	4	4	3	..	3	4	..	..	3.6
(2)	6	7	7	7	5	5	..	..	6.1
(3)	10	9	9	7	5	5	..	..	7.5
(4)	9	8	10	9	9	7	..	..	8.6
(5)	10	11	10	9	10	10	..	..	10.
			Average width of cells,	-	-	-	-	-	7.16

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical						Basal		Average
(Ep)	2	3	2	3	2	3	..	..	2.5
(2)	7	5	5	8	5	5	..	..	6.
(3)	6	6	8	9	7	8	..	..	7.3
(4)	6	7	7	7	8	10	..	..	7.5
(5)	5	7	9	10	10	10	..	..	8.5
(6)	11	12	13	11	11	10	..	..	11.3
			Average width of cells,	-	-	-	-	-	7.18

The data given in the above table show that whatever inequality has been present in the curved portion of the root during the first stage of curvature the subsequent processes have reduced this inequality to a minimum. The greater length of the cells of the concave side may not be held to have special significance, since similar inequalities are to be found between the sides of normal roots. The width of the cells of both sides is below the normal, and by no means sustains the proportions to the length to be found in other curvatures. This can be due only to the fact that both sides in succession have been subjected to a ductile stretching, and that the extension of the cells may not be taken up, but is irreversible after the lapse of five hours. The processes of growth then follow the extension of the membranes within this period. The foldings of the walls in the above sections are not especially marked.

TABLE XIII.

Median longitudinal section of root of *Phoenix dactylifera* geotropically excited twenty hours and curved through 90°.

MEASUREMENTS OF WIDTH OF CELLS OF CONVEX SIDE.

	Apical							Basal	Average
(Ep)	8	9	8	7	7	7	7	7	7.5
(2)	10	9	8	6	7	8	8	7	7.8
(3)	5	5	5	7	5	6	5	5	5.4
		Average width of cells,			-	-	-	-	6.9

MEASUREMENTS OF WIDTH OF CELLS OF CONCAVE SIDE.

	Apical						Basal		Average
(Ep)	10	10	8	8	8	8	7	..	8.4
(2)	9	10	8	9	10	8	9	..	9.
(3)	7	7	7	6	5	5	6	..	6.1
		Average width of cells,			-	-	-	-	7.8

MEASUREMENTS OF LENGTH OF CELLS OF CONVEX SIDE.

	Apical						Basal		Average
(Ep)	8	9	10	7	7	7	7	..	8.
(2)	10	12	11	15	13	15	13	..	12.7
(3)	15	15	10	15	15	20	20	..	15.7
		Average width of cells,			-	-	-	-	12.1

MEASUREMENTS OF LENGTH OF CELLS OF CONCAVE SIDE.

	Apical						Basal		Average
(Ep)	3	2	2	2	2	3	2	..	2.3
(2)	5	6	3	3	4	5	8	..	4.8
(3)	7	7	7	6	5	4	3	..	5.5
		Average length of cells,			-	-	-	-	4.2

TABLE XIV.

Median longitudinal section of *Phoenix dactylifera*, same as table XIV. The region from which measurements were made was halfway between the endodermis and cortex. The rows of cells apparently of maximum size were measured.

MEASUREMENTS OF CELLS OF CONCAVE SIDE.

Length	9	5	6	4	5	5	4	7	9	9
		Average length, - - - - - -								6.3
Width	12	13	12	11	13	12	12	10	11	10
		Average width, - - - - - -								11.5

MEASUREMENTS OF CELLS OF CONVEX SIDE.

Length	20	18	20	17	18	20	21	18	12	15
		Average length, - - - - - -								17.9
Width	20	20	20	14	15	12	13	12	13	13
		Average width, - - - - - -								15.2

The curvatures of Phoenix offer distinct variations from those of Zea, of which the most striking is the extensive development of the cortex on the convex side of the root.

The width of the layer external to the stele on the convex side is 30 and on the concave side 25. This difference is shown also by the measurements of the individual layers of cells. The radial diameters of the epidermal and sub-epidermal cells of the concave side are slightly in excess of those of the convex side, but it may be seen very plainly that the changes in these cells are purely passive and mechanical. The differences between the longitudinal diameters of these cells are of course in favor of those of the convex side, and the changes in form of the cells of these layers are almost exactly in imitation of the folds of the bellows of an accordion.

The force operative in producing curvature is to be found in the cortical cells between the fifth and sixth layer from the epidermis and the endodermis, and whatever the nature of the changes involved, it is found that an extension of the cells of the convex side in both a radial and longitudinal direction occurs.

It is important to note that this is the first establishment of the fact that the radial diameter of the convex side of any root becomes greater than that of the concave side. Cieselski affirmed the same fact concerning Zea, Phaseolus, and Pisum in 1871, but it was disproven by Sachs a year later, and recently by myself in the same plants. It had come to be regarded, therefore, as a well founded fact that the radial diameters of the convex sides of stems increase during curvature and those of roots decrease, and that while the longitudinal diameters of the cells of the convex side of roots increased the radial diameters did not change or decrease, while exactly the reverse conditions were to be found in the concave side.

It is noteworthy in this connection that the roots offering similar conditions to stem curvatures exhibit similar reactions, and it seems reasonable to conclude, therefore, that since the morphological character of the tissues involved is not always identical, this similarity in behavior is founded upon mechanical necessities. Furthermore, it is to be said that the roots of Phoenix offer unmistakable evidence of the shortening of the concave side.

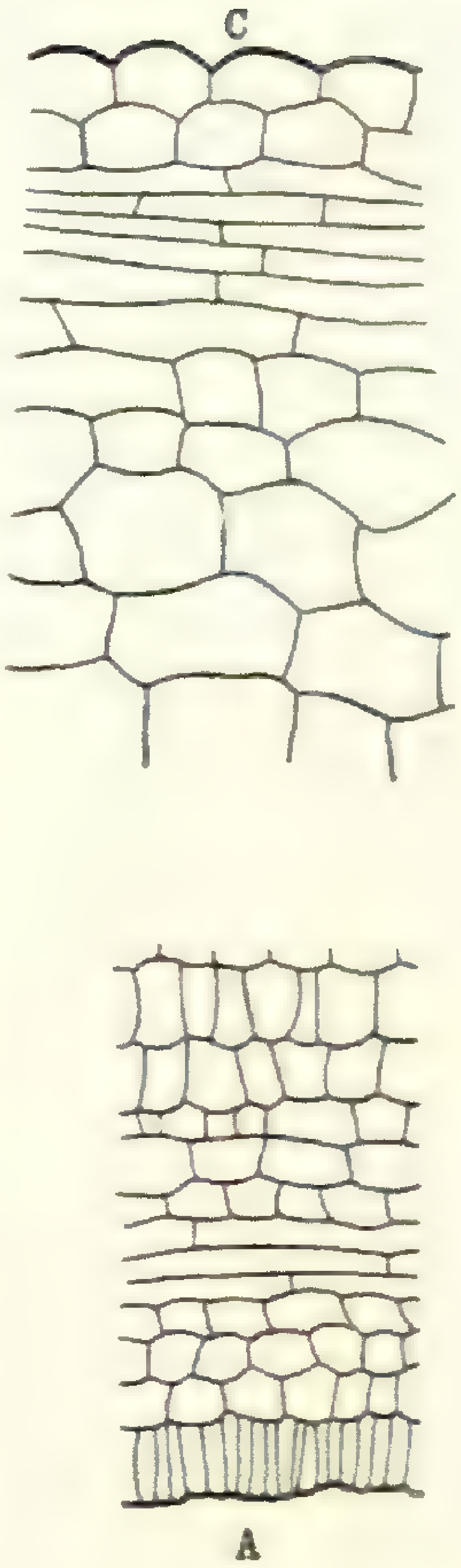

FIG. 7. Median longitudinal section of curved portion of root of *Phoenix dactylifera* twenty hours after the beginning of excitation. *C*, convex side; *A*, concave side (see tables XIII, XIV).

XIV. INTERPRETATION OF EXPERIMENTAL RESULTS.

The most important question involved in the solution of the various problems connected with curvature is the determination of the nature of the changes involved in the extension of the cells of the convex side of the organ, to ascertain whether the elongation of the membranes is due to the actual intussusception of new material, or whether the membranes undergo induced changes of elastic extensibility, which finally becomes converted into ductility. The last method has been somewhat conclusively demonstrated by Noll in stems (16). The chief evidence upon which this conclusion rests consists in the fact that the epidermal and collenchyma cells of the convex side show an enlargement of three diameters during curvature, and that the enlargement is accompanied by a decrease in the thickness of the cell walls. Not only are the membranes of the convex side thinner than those of the concave side, but they are thinner than those of normal tissues of the same stage of development. The extension is also accompanied by changes in the qualities of the membranes, as shown by refraction and reaction of staining fluids.

In the application of the same tests to the curvatures of roots some difficulty is encountered on account of the relatively small thickness of the walls; furthermore, the different condition of the tissues must be taken into account. In stems the epidermis and collenchyma are in a state of active growth which may be maintained for a long period, and these layers may elongate during curvature with a rapidity equal to that of the cortex, and they may not; in the latter instance they will experience stretching tension from the cortex. In roots, on the other hand, the epidermal and sub-epidermal layers are not in a state of rapid elongation, but have attained the greater part of their growth; furthermore, these cells are capable of active enlargement during a period of one or two days at most, and are then cast away. In consequence of this fact the peripheral layers of cells undergo a passive stretching on the convex side which increases the axial and decreases the radial diameter. The reverse is true of the concave side. The underlying layers of cortex in Zea undergo an axial extension in the convex side, and a radial extension of the concave side. Alterations in the radial diameter of the first and the axial diameter of the second are not exactly ascertained, but the amount of change must be very slight. The roots of Phoenix have a much greater relative thickness than those of Zea, and are furnished with a layer of sclerenchymatous tissue underneath the epidermal layers. The epidermal system exhibits similar reactions to those of Zea, except that the changes are relatively greater than in Zea, due no doubt to the greater thickness of the root and the consequent greater distance of the epidermis from the central cylinder. The arms of the lever extending from the periphery of the concave to the convex side would be twice as long as that of Zea. The above differences are mechanical, but the cortex of Phoenix also offers distinct differences in behavior from that of Zea. The axial diameter of the cells of the concave side has not increased, and is not greater than that of the same region apical to the curvature. The increase of the radial diameter has been very slight. The cells of the cortex of the convex side have increased in radial as well as axial diameter, in a manner similar to that in stems as described by Kohl (12), and by Noll (17). It is difficult to account for the similarity of the behavior of the curvatures of roots of Phoenix and dicotyledonous stems, except as a concomitant of the mechanical structure, though the real necessities are not apparent.

Differences in the quality of the membranes are not so easily distinguished in young roots as in old stems. The sections of the roots of Zea which have been excited geotropically for three hours and stained in Bismarck brown exhibit slight differences between the cortex of the convex and concave sides. Those of the concave side have taken the stain more deeply and are thicker than those of the convex side. After remaining forty-eight hours in alcohol the membranes of the convex side appear only slightly tinted and are not so highly refractive as those of the concave side, which are still more deeply colored. These results do not bear strict comparison with the reactions of stems, since the action of the agents used in killing and imbedding might cause some alterations in the physical properties. From the great amount of data given in the foregoing tables it is possible to obtain some evidence bearing upon the question. The following table presents the general results obtained from the measurements of Zea.

TABLE XV.

MEASUREMENTS OF CELLS IN CURVED PORTIONS OF ROOTS OF ZEA.

	Convex	Concave	Convex	Concave
Normal roots, - - - - - -	(14.82	11.35	8.29	8.047)
Recurved to 15°, - - - - - -	56.04	57.77	7.16	7.18
Geotropically curved 60°, - -	43.3	29.9	7.56	8.29
Mechanically curved 90°, - - -	61.4	56.85	6.98	8.04
Geotropically excited and mech. curved,	44.63	30.32	7.91	9.3
Geotropically curved 105°, - - -	48.05	24.7	6.98	11.4
Geotropically curved (old) 90°, -	71.99	45.00	8.53	11.69
Geotropically curved (old) 160°, - -	78.75	25.28	10.05	12.52

The comparison of the measurements of the cells of a region allowed to curve five hours, and then in the opposite direction for fifteen hours, with the curvatures of three and twenty hours duration is of interest. The length attained by the cells of the convex side in three hours is 43.3, and of the concave side is 29.9. The length of the cells of the concave side after recurvature of the portion apical to it is 57.7, and of the convex side 56.04. If it be taken for granted that the two measurements are of regions strictly correspondent, it can be assumed safely that during the five hours in which curvature was allowed to proceed normally the length of the cells of the convex side became greater than 43.3, and of the concave side greater than 29.9. On the reversal of the root and its excitation in the opposite direction, a curvature would be induced in a region a distance apical to the curvature of the shortest radius, by the amount of growth elongation of the tip of the root during five hours. The region of the new curvature would not be identical with that of the old, but would overlap a portion of it and extend apically a short distance. The new changes set up would affect the entire region of the old curvature by the mechanical strains set up. The compression of the concave side would be released, and the stretching of the convex side would be met. It would appear, therefore, that the cells of the convex side had undergone no contraction on the release of the first excitation, and had grown from 43 to 56 in fifteen hours. Then the cells of the concave side on release from the compression have undergone an extension by which their length has been approximately doubled, and is in excess of the actual length of the cells of the convex side.

The conclusion is warranted that the excitation of the root in a direction opposite to newly formed curvature does not result in a straightening of the curvature by the relaxation or contraction of the extended convex cells, after a period of growth has ensued. The straightening of the curvature is due to the accelerated elongation of the concave side in the same manner as in the formation of the original curvature. A compression or shortening of the convex side does not occur until the concave side has extended sufficiently to compress it mechanically. It is pertinent to state here that anything like an active contraction or relaxation of the cells on the side becoming concave either in curvations or recurvations is not to be found in roots. On this account the straightening of curvatures by recurvation is not to be adduced as evidence that curvature is due to elastic stretching in the manner in which it has previously been done by Sachs, Noll, and others. Furthermore, my preparations show that the walls of the originally convex side have lost their attenuated condition, and that the cells of the originally concave side have taken up this character. The straightening of curvatures by plasmolysis is an altogether different process, since in this manner the greater elastic stretching of the convex side would be directly released, and would allow the root to return to a position determined by the physical characters of the wall. The complications which attend the plasmolysis of tendrils (14) would be wanting, and the straightening of the curvature in this manner, as well as the difference between the membranes of the convex and concave sides, would justify the conclusion that the curvature is due to the elastic stretching of the convex side of the root, and that this elastic extension was fixed or held in an elongated position by the loss of elasticity in any one of many ways; by changes of the quality of the wall induced by the ectoplasm, or by the intussusception or apposition of new building material. The weight of evidence obtained by Noll and myself is in favor of the first named method.

The exact region of the motor zone which is set in activity by the impulse from the sensory zone embraces a part of the cortex consisting of the fourth to the eighth layer of the cortex in Zea, and from the fifth to the tenth or eleventh layer in Phoenix. The changes consequent upon a reception of an impulse occur in the walls of these cells only, and their active extension results in the stretching of the external or peripheral layers.

It must be supposed that the increase in elasticity extends to the radial walls in Phoenix. The folding of the walls of the motor cells of roots is doubtless due to the great resistance to their expansion offered by the peripheral layers. Marked or sharply folded walls are not to be found in the convex sides of stems and other organs in which all of the tissues are more or less active in the elongation.

The comparatively great radial growth of the epidermal cells of the concave side subsequent to curvature must be taken as a consequence of the mechanical strain exerted upon this layer.

XV. RECAPITULATION.

The contents of the foregoing paper may be summarized briefly in the following paragraphs:

1. In order to determine the nature and mechanism of a curvature, the phylogenetic meaning and purpose of the movement, the arrangement of the mechanical tissues, and the stage of development of the organ must be taken into consideration. The curvatures of stems are not identical with those of most tendrils, or of many roots.

2. It has been established beyond all doubt, by previous investigations, that curvatures are due to changes in the cell wall, rather than in the osmotic activity of the cell contents. The only determination of the real nature of curvature is to be accomplished by an anatomical examination of the cells of the motor zone before, during, and after curvature has taken place.

3. The development and organization of irritability in roots and shoots has been widely different. The segmentation and branching of the shoot, in order to facilitate food formation and reproduction, has been accompanied by an isolation and separation of the forms of irritability, a great extension of the sensory surfaces, and a less widely extended distribution of motor regions. The development of the root in order to facilitate absorption has resulted in a coincidence of many forms of irritability, both as to sensory and motor regions in the extreme apex of the growing organ which undergo branching but no segmentation.

4. The organs of the irritable mechanism of roots exhibit a physiological rather than a morphological differentiation.

5. The sensory zone. The mass of protoplasts of the root capable of converting certain external forces into forms of energy which induce movement constitutes the sensory zone. The term "perceptive zone" has hitherto been improperly applied to this region. Roots exhibit reaction to injuries which cut away a thin slice of the periblem, and to incisions in the periblem which do not affect the *punctum vegetationis*, as well as to incisions which cut away the *punctum vegetationis* entirely. Furthermore, injuries directly apical and affecting the *punctum vegetationis* alone do not cause reaction, and it is probable that the *punctum vegetationis* does not form an essential part of the sensory zone. The sensory zone, therefore, consists of a cup-shaped mass of periblem extending 1 to 2^{mm} axially, from which the bottom, represented by the *punctum vegetationis*, is lacking. The sensory zone extends approximately to the forward edge of the motor zone.

6. Transmission of impulses and latent period. The latent period of the reactions of roots varies from one to fifteen hours according to the nature of the stimulus and the mechanical qualities of the root. The latent period of geotropic reactions of Zea may be no more than one hour, of traumatropic reactions ten hours. The contiguity of the sensory and motor zones renders no special provision for the transmission of impulses necessary, and leads to the conclusion that the greater portion of the

latent period is consumed by the preliminary changes in the motor zone.

7. The motor zone. The movement of a root is caused by changes in the region in which the energy of the periblem is turned from cell division to cell enlargement. The motor zone includes a length of 2–3^{mm} of the root. The curvatures of roots apical and basal to the motor zone are mechanical accompaniments of the action of the motor zone.

8. The mechanism of curvature. The curvature of roots is due to the excessive active elongation of the internal layers of the cortex, of the side becoming convex, made feasible by the increased stretching capacity of the longitudinal membranes. The extension of the membranes is accompanied or preceded by changes in the quality of the membranes as indicated by their reaction to staining fluids. In consequence of the stretching the membranes of the convex side become thinner. As a later effect of the compression upon growth of the concave side, the membranes of that side become thicker. Seventy to one hundred hours later the difference is obliterated by growth.

The peripheral layers of the convex side are stretched passively in the longitudinal axis, and decrease in radial diameter during curvature. The peripheral tissues of the concave side are compressed longitudinally and show an increase in radial diameter during curvature. Roots with a peripheral layer of mechanical tissue exhibit only a slight increase of the radial diameter of the concave side and a marked increase of the radial diameter of the inner layers of cortex of the convex side. Roots without a peripheral layer of mechanical tissue exhibit a marked increase of the radial diameter of the inner cortex of the concave side, and a decrease of the radial diameter of the cortex of the convex side.

9. Recurvatures of stems in response to an excitation to movement in a direction opposite to the first curvature are not accompanied by a relaxation of the extended cells of the convex side of the first curvature, but by the greatly accelerated extension of the forward cells of the sensory and motor zones,

and render a second curvature in any region after an interval of three or more hours impossible. Recurvature in response to excitation is not therefore similar to straightening by plasmolysis.

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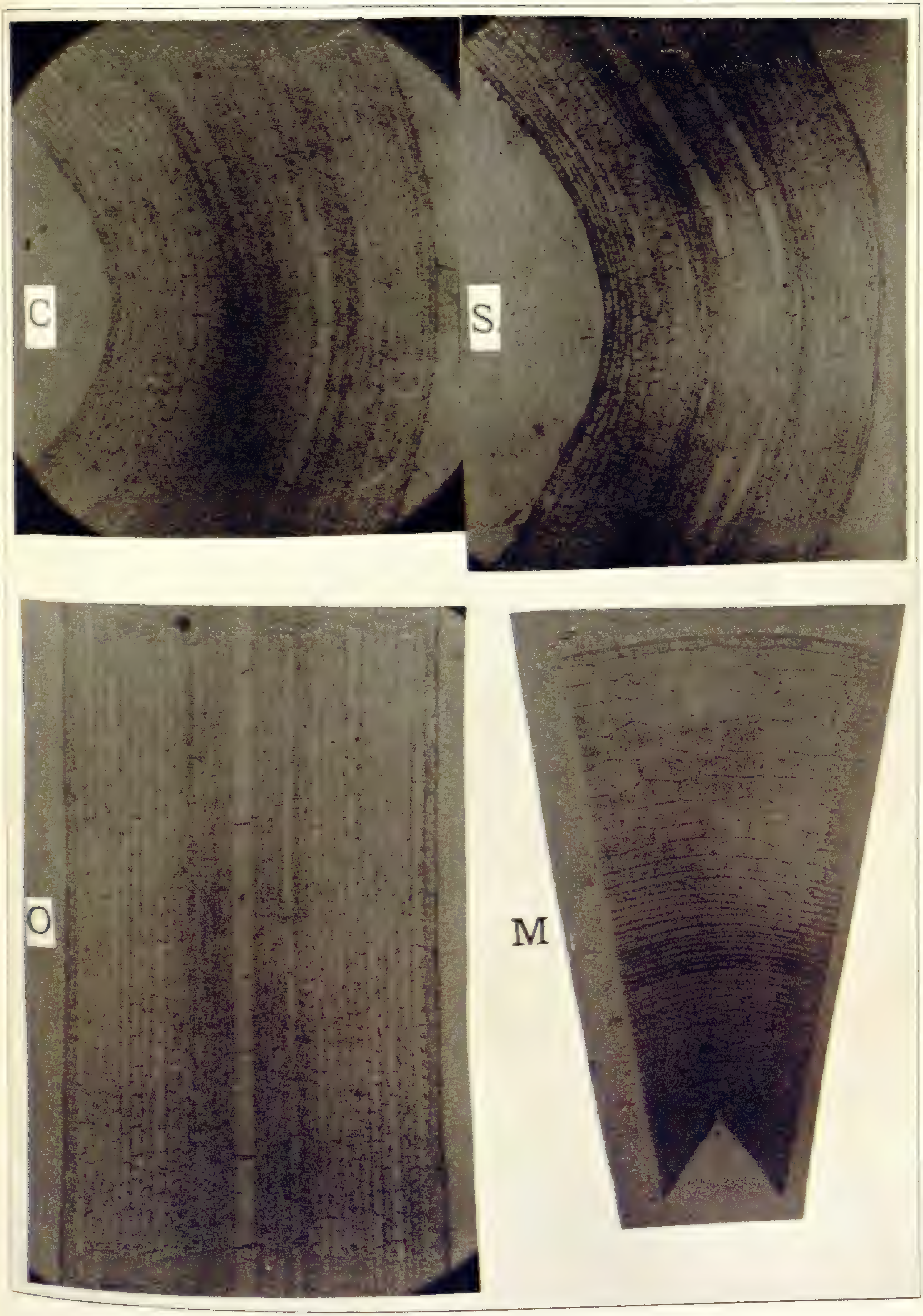
EXPLANATION OF PLATE XXVIII.

C. Median longitudinal section of motor zone of root of Zea geotropically excited and curved through 105°. The epidermal cells of the convex side have collapsed. A few root hairs are to be seen on the basal end of the motor zone. After a photomicrograph.

S. Median longitudinal section of motor zone of Zea geotropically excited and curved through 60°. The epidermal cells of both sides are normally turgid, and both exhibit root hairs. The differences between the contours of the cortical cells of the convex and concave sides are not so apparent as in C. After a photomicrograph.

O. Median longitudinal section of motor zone of straight root. After a photomicrograph.

M. Cieselski's drawing of a median longitudinal section of motor zone of Zea. "*Ep*, epidermis; *rp*, cortical parenchyma; *gbs*, endodermis; *lzb*, fibro-vascular bundle; *h*, wood cells; *g*, vessels. The cells of the half toward the nadir are smaller than those of the side toward the zenith; the cells of the upper half are stretched uniformly, while those of the under side are irregularly folded. The contents are much denser than of the upper side."



MacDOUGAL on ROOT CURVATURE.

BRIEFER ARTICLES.

ACROSPERMUM URCEOLATUM, A NEW DISCOMYCETOUS PARASITE OF SELAGINELLA RUPESTRIS.

(WITH PLATE XXIX.)

On some material of *Selaginella rupestris* (Linn.) Spring. recently examined a small discomycetous fungus was discovered which at once aroused inquiry from its occurrence upon a plant so rare as a host.

The characteristic features of the plant show it to be an Acrospermum, but there is no record of such a fungus upon Selaginella, and it does not correspond to any of the described species. The material on which it was found was collected at Taylors Falls, Minnesota, in August 1896, and had been preserved in 80 per cent. alcohol for several months when it was brought into the laboratory for use and the presence of the fungus was discovered.

The family Acrospermaceæ[1] is of particular interest because of its intermediate position between the Pyrenomycetes and Discomycetes. In this genus especially the early stages show an intimate connection with the closed apothecia of the Pyrenomycetes, while the development of a broad ostiole in the mature forms indicates relationship with the open disklike ascoma of the Discomycetes.

Through such a transitional form the closed indehiscent perithecium of the Erysiphe type connects with the saucerlike Peziza forms, and there is some doubt whether the term "apothecium" is the correct one to use, but with this reservation it will be employed.

The apothecia studied appear upon the leaves of the host as small dark bodies, the size of a pin head, and upon examination a branch of infected material plainly shows the presence of the parasite by the dark spotted appearance of the leaves. This is due to the young apothecia on the inner side, but many of the larger ones protrude from between the leaves and can be teased out readily with a needle (*fig. 1*).

The plant is epiphyllous in its habit, and no evidence could be obtained of its entering deeply the tissues of the host. It is somewhat difficult to detect the mycelium, but after soaking the infected leaves in potassium hydrate for several days enough of the chlorophyll was removed to enable one to distinguish the hyphæ. A full-grown apothecium was loosened from a leaf without removing it entirely, and upon examination it showed that only the epidermis of the host, covered with the fungus mycelium, was torn away with the apothecium (*fig. 2*).

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[1] Rehm. Rabenh. Krypt. Fl. 1^3: 53. 1887.

The general appearance of the young apothecia indicates that they are developed superficially by the formation of a knot of hyphæ.

The mycelium is so densely interwoven in the immediate region of the apothecia that an examination is somewhat difficult, but a few mounts were secured, showing it to consist of irregularly branching hyphæ, very small and of slightly greenish tinge, similar in color to the apothecia. The hyphæ are so dark colored that it was not easy to determine whether the mycelium is generally coenocytic or multicellular, but a few septations could be made out (*fig. 3*).

The mature apothecium is stalked, but in younger stages, previous to the development of the spores, and even earlier, when the contents of the apothecium are not yet differentiated into asci, the width is so nearly the same along the entire length that the stalk cannot be distinguished from the body. The hyphæ by which the stalk is attached to the mycelium are densely interwoven at the base, and often several apothecia are connected so that when torn away from the host they still adhere to one another by this mycelial mat (*fig. 4*), which forms, as it were, the beginnings of a stromatic cushion. The surface of the apothecium is rough and the wall is friable; it is dark olive green, the upper part being covered with a white, granular tomentum. The general outline of the apothecium is that of a vase. Dehiscence is apical, with the development of an ostiole, which does not appear till the apothecium has almost attained its growth and the asci and spores have been differentiated. The youngest apothecia observed appear as tiny dark projections on the surface of the leaf; these elongate into club shaped bodies, but as yet show no signs of an ostiole. It would seem that the apothecial wall becomes thinner at the apex as lateral growth increases, is finally ruptured and spreads outward near the top, giving the apothecium the appearance of being compressed just below the ostiole.

The size varies from 550–800μ in length by 220–400μ in diameter at the widest part. The measurements for length include the stalk. In one apothecium 800 × 320μ the stalk was 160μ long.

The number of apothecia found upon a single leaf varies from one to six or seven. When more than one are present they may be solitary or aggregated into groups, as described above. They occur on both sporophylls and foliage leaves, and always on the upper side. When found on the sporophylls they are grouped about the sporangium of the host, but in none of the material examined were apothecia seen growing upon the sporangium itself (*fig. 5*).

The asci are numerous, a hundred or more in each apothecium. By soaking some material in potassium hydrate for several days the apothecial wall becomes sufficiently cleared to reveal the arrangement of the asci within. They lie parallel in the body of the apothecium, closely crowded together and extending almost to the ostiole (*fig. 6*). When the asci are released through the side by breaking open the apothecium they escape in masses, clinging together, with numerous paraphyses. These are about a third or a fourth the length of the asci, delicate, threadlike, hyaline. The asci vary from 220–320μ long by 5–8μ wide. One ascus showed a curious branching near the end (*fig. 7*).

The spores are long and slender, extending the entire length of the ascus, but the whole group of spores is generally so twisted that it is extremely difficult to determine their number, as it is almost impossible to remove them from the ascus without entirely crushing them (*fig. 8*). In one such attempt the broken ends of at least six spores could be distinguished (*fig. 9*).

Another method employed was to embed the apothecia in paraffin, and with the microtome cut a series of transverse sections, thus obtaining cross sections of the asci. Two of these sections revealed seven spores in the one case and nine in the other (*fig. 10*).

The spores are multiseptate and hyaline, so that when they are twisted the septations of the under ones can be seen through the upper ones, giving them a guttate appearance.

After careful study of descriptions and comparison with herbarium material, the habit of growth, character of the apothecium, ascus, and spores, clearly place the plant studied in the genus *Acrospermum* Tode, of which the following description is translated from Saccardo[2], who places these plants in the Hysteriaceæ among the Pyrenomycetes, with which, as with the Hypocreaceæ[3], they have at different times been classified:

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[2] SACCARDO, Syll. Fung. 2:807. 1883.

"Perithecia vertical, elongated or clavate, sessile or stalked, leathery. Asci filiform, eight-spored. Spores crowded together, parallel, filiform."

So far as could be determined there have been only sixteen species described, of which three are doubtful. The following eight are recorded from America:

ACROSPERMUM COMPRESSUM Tode Fung. Meckl. **1**: 8. *pl. 2. f. 13.* 1790. On Cucurbitaceæ, Pisum, *Urtica dioica*, and Umbelliferæ; also on various grasses and leaves of Olea.

ACROSPERMUM GRAMINUM Lib. Exs. Ard. n. 33. Corda. Ic. Fung. **3**: 27. *f. 73.* 1839. On Poa, Festuca, Calamagrostis, Triticum, etc.

ACROSPERMUM RAVENELII B. & C. Grev. **4**: 161. 1876. On Cercis, Vitis, and Fraxinus.

ACROSPERMUM FOLIICOLUM Berk. Grev. **4**: 161. 1876. On Ulmus and Celtis, Vitis, and Smilax.

ACROSPERMUM VIRIDULUM B. & C. Grev. **4**: 161. 1876. On stems of dead shrubs and herbs, and on leaves of *Pyrus communis*, Hicoria and Quercus.

ACROSPERMUM CORRUGATUM Ell. Bull. Torr. Bot. Club. **8**: 124. 1881. On decayed wood and Umbellularia.

ACROSPERMUM FULTUM Harkn. New Calif. Fungi 26. ——. On Eucalyptus.

ACROSPERMUM ALBUM Peck. 32d Rep. N. Y. Mus. Nat. Hist. 38. 1879. On *Aralia racemosa*.

The herbarium material studied for comparison includes the following species: ACROSPERMUM COMPRESSUM Tode (Ellis, *North Amer. Fungi*, no. 1318, on *Cinna arundinacea;* C. Rouméguére, *Fungi Gallici exsiccati*, no. 1851, on *Urtica dioica;* Krieger, *Fungi Saxonici*, no. 438, on *Lunaria rediviva*), ACROSPERMUM CONICUM Fries (*Reliquiæ Mougeotianæ*, no. 24, on *Sonchus alpinus*); ACROSPERMUM CORRUGATUM Ell. (Ellis and Everhart, *North Amer. Fungi*, no. 2055, on *Umbellularia Californica*); ACROSPERMUM FOLIICOLUM B. and C. (Ellis and Everhart, *North Amer. Fungi*, no. 2629, on leaves of Ulmus; no. 2149, on Concord grape); ACROSPERMUM GRAMINUM Lib. (Sydow *Mycotheca Marchica* no. 1957, on *Triticum viridulum*); ACROSPERMUM VIRIDULUM B. and C. (Ellis, *North Amer. Fungi*, no. 857, on *Pyrus communis*).

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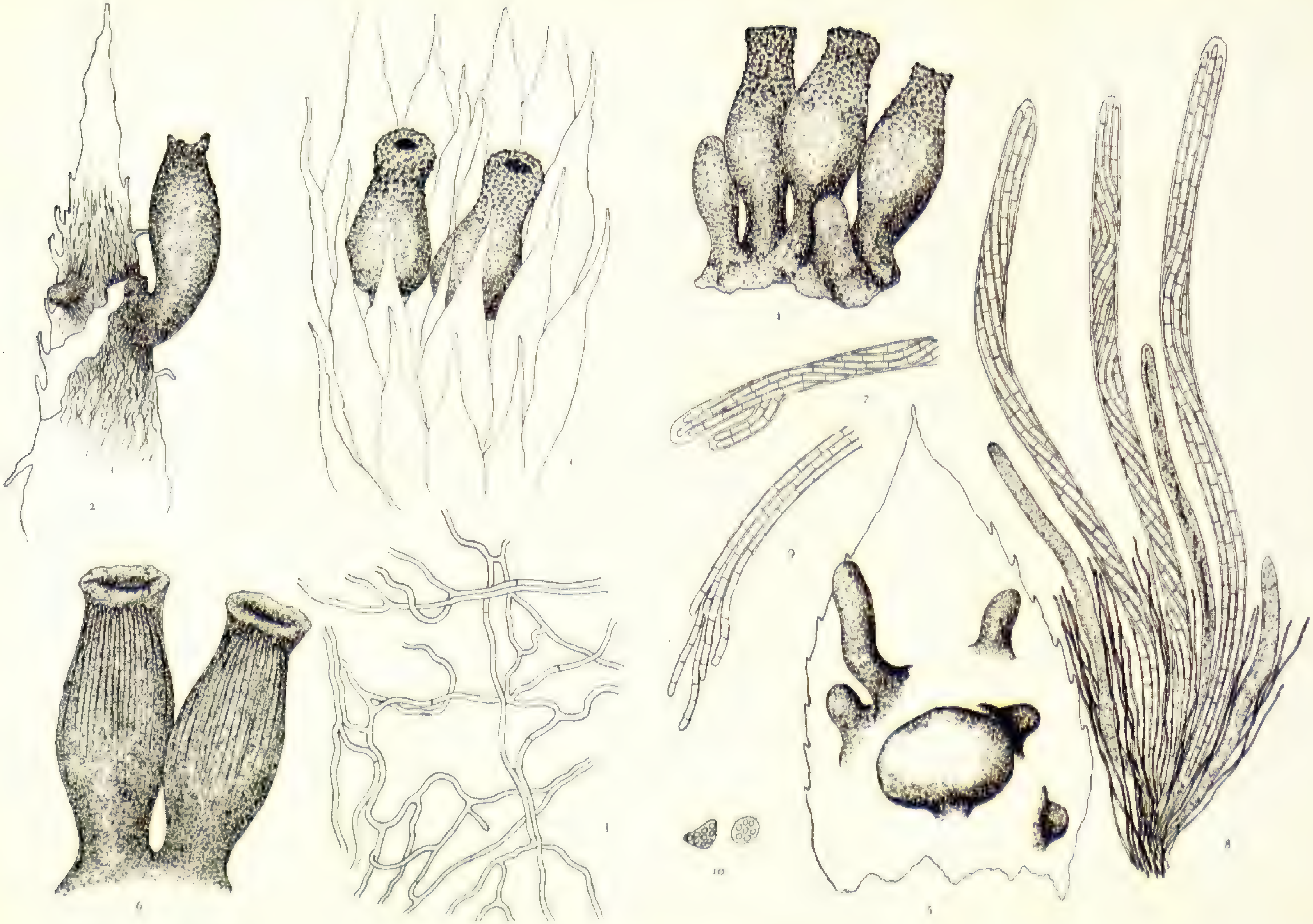
[3] ELLIS and EVERHART, North Amer. Pyrenomycetes 58. 1892.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ACROSPERMUM URCEOLATUM Olson, n. sp.

The two species which the plant under consideration most nearly resembles are *Acrospermum viridulum* B. and C. (but the apothecia, asci, and spores of the new plant are too large to justify its classification here) and *Acrospermum fultum* Harkn. (but the shape of the apothecium and measurements of the paraphyses exclude it from this species).

Acrospermum urceolatum, n. sp. — Apothecia solitary or aggregated into small groups, elongated vertically, stalked when mature, with distinct ostiole, below somewhat compressed, giving a vaselike appearance; young apothecia approximately hemispherical, lengthening and becoming club shaped before the appearance of the ostiole, dark olive green, upper part covered with white granular tomentum, 550–800μ in length by 220–400μ in diameter at the widest part; asci many, elongated and cylindrical, tapering at the lower end, crowded closely together, of nearly the same length as the body of the perithecium, 220–350μ × 5–8μ, accompanied by delicate threadlike unseptate paraphyses 1.3μ in diameter and one-third to one-fourth the length of the asci; spores hyaline, filiform, very slender, 1.6μ in diameter, of the same length as the ascus, multiseptate, generally curved, rarely lying straight throughout the length of the ascus.

On leaves of *Selaginella rupestris* (Linn.) Spring. Taylors Falls, Minnesota. Coll. Conway MacMillan. August 1896.—MARY E. OLSON, *University of Minnesota.*

EXPLANATION OF PLATE XXIX.

FIG. 1. Appearance of mature apothecia on a branch of the host, showing ostiole and granular tomentum (dry). × 38.

FIG. 2. Mature and rudimentary apothecia attached to the host by dense mycelial weft (water mount). × 54.

FIG. 3. Mycelium. × 334.

FIG. 4. Group of apothecia connected by mycelial mat. × 38.

FIG. 5. Young apothecia growing on a sporophyll, grouped about the sporangium of the host. × 38.

Fig. 6. Mature apothecia soaked in KOH, showing arrangement of the asci. × 134.

FIG. 7. Branched ascus. × 334.

FIG. 8. Three mature and three young asci, with paraphyses, spores curved within the asci. × 334.

FIG. 9. Ascus broken, showing the ends of six spores. × 334.

FIG. 10. Cross sections of asci, showing the number of spores. × 334.

THE PREPARATION OF MATERIAL FOR GENERAL CLASS USE.

THE preparation of material for studies of structure, development, and embryology, for general course students, or for advanced courses where the primary object is to give the student an opportunity to examine as large a series of forms as possible, in order to pave the way for broader generalizations, and yet allow him to do a considerable portion of the work, especially that of the final preparation of the specimens, has been a problem of some little difficulty with me, and which is perhaps shared to some extent by others. One may depend on material simply preserved in alcohol, which the members of the class may section as best they can free hand, but this method does not give such good preparations usually as sections made by some method of precision, though it is a very useful thing to know how to make free hand sections well.

Several laboratories have had recourse to freezing microtomes, or rather to cutting frozen plants with the microtome. This is usually done by the instructor or assistant, and the sections are distributed to members of the class, where the final treatment is given by each individual. This, it has seemed to me, is an excellent method, and while the student does not ordinarily do the sectioning, each one usually has an opportunity to see how the material is oriented, and can in this way gain a good notion of the relation of the section to the part of the plant cut. So well did I think of this method that I was about to introduce it into our laboratories when another method upon which I had been working for about two years seemed to me to be in general a better one, and it has been largely adopted in my general classes. It is understood, of course, that when an individual comes to take up work of the nature of investigation, all the processes involved in the preparation of the material are required to be conducted by him. Usually, also, in the advanced courses which precede investigation, each student is called upon to carry several forms through all the necessary processes of fixing and manipulation, so that there may be some training in methods preliminary to the later work of investigation. It this way persons who later do not take up special lines of investigation will have an opportunity of studying a larger number of forms than would be possible if it were insisted that all the work of preparation should be required, and at the same time there is some practical knowledge of methods which is especially useful to those who are looking forward to teaching in the secondary schools.

The method is, in brief, to carry the material through all the processes of fixing, dehydration, and infiltration, with some medium in which the sections can be made and have the material ready to section at a moment's notice: not simply to prepare enough material for the use of the class of one year, but to prepare a sufficient quantity at once to meet the wants of a class of ten to twenty students for a period of years. Take for example, among the bryophytes, such liverworts as Riccia, Marchantia, Preissia, Pellia, Pallavacinia, Ptilidium, Cephalozia, etc. To obtain material for classes in several stages of development takes a considerable amount of time. When the material is once found in quantity it requires but little more time to carry through a large amount which will last for a period of years than to prepare just enough for one year. And this is the principle which I have adopted in the preservation of material for class study. The greater amount of material has thus far been prepared by the collodion method, and when once imbedded in collodion the blocks containing the plant parts ready for sectioning are stored in 80 per cent. alcohol, and then are ready to cut on a moment's notice and to serve to the class. For certain material collodion is excellently adapted, while for other material it is poorly adapted, and I have been obliged in many cases to resort to paraffin imbedding, which is far superior for certain kinds of work.

It is unnecessary to give here in detail the processes of fixation, dehydration, and infiltration in collodion. These are sufficiently well known or can be obtained from the books. But it may not be amiss to give briefly the method which I have recently adopted with success in imbedding large quantities of material at one time in collodion. I use collodion made by dissolving ordinary gun cotton in equal parts of 95 per cent. alcohol and ether: two solutions, a thin one of 2 per cent. consistency (2 grams gun cotton to 100^{cc} alcohol and ether), and a thicker one of 5 per cent. consistency.

The objects are previously trimmed to the desired size and form for sectioning. From the vial which holds them the 95 per cent. alcohol is decanted, and if there is considerable bulk of tissue an amount of ether approximately equal to the estimated amount of alcohol remaining in the tissues is added before pouring on the 2 per cent. collodion. This prevents an excess of alcohol which flows out of the tissues from coagulating a film of collodion on the outer surface which would interfere with infiltration. The objects may remain in the 2 per cent. collodion for twenty-four hours to several days or weeks at pleasure. The 2 per cent. is decanted, and the 5 per cent. poured on, which also may remain for twenty-four hours or more. Care should be used to prevent evaporation in the storage bottles of collodion, or in the vials during infiltration. After replacing the corks the bottles can be inverted for a moment, and the collodion running around the cork seals it. The objects are now poured with the 5 per cent. collodion into shallow paper boxes, the latter being received into vessels ordinarily employed as moist chambers, though there should be no water in the chambers. Here they are allowed to remain for two days or so while the collodion slowly thickens to the desired consistency, when the boxes are immersed in 95 per cent. alcohol for about twenty-four hours. The paper is now stripped from the block of collodion, and the latter is stored in 80 per cent. alcohol.

The paper trays should be lubricated previously on the inside with vaseline so that the paper will easily part from the collodion. The vessel used for a moist chamber should be one which can be partly opened at the top, never at the bottom, for the circulation of air, so that the thickening of the collodion will not be unnecessarily prolonged, and at the same time it must be slow enough to permit all air bubbles, which may be present when the material is poured in the trays, to rise to the upper surface and disappear, and also to permit an even thickening of the collodion lest an outer layer is hardened quickly which prevents the proper hardening of the interior. The trays should be of such depth that they may be filled at once with an amount of collodion which when thickened will be of the desired thickness for sectioning. I usually employ trays from 10 to 15^{mm} deep. If there is not sufficient 5 per cent. collodion in the vial at the time to fill the tray more is added. The trays vary in size according to the amount of material to be imbedded, and frequently several trays are used for one lot of material. The trays may vary from 5–10^{cm} long by 3–8^{cm} in width. As soon as they are filled with the collodion a small needle is employed to adjust the objects in convenient position for orienting, and at such distances that each may be cut out in a block of hardened collodion of such a size as to fit directly in the jaws of the microtome. It thus requires but little time to place the material in the trays in the nearly closed receptacles where evaporation may go on slowly, and there is no danger that the material will become too hard and dry if it should be overlooked for several hours beyond the usual time required for thickening. Where large trays are needed, I have several times employed Petrie dishes with success.

The material is thus ready for use on the shortest notice, and a sufficient amount for several years. When it is to be used the assistant cuts out an object in a block of collodion of convenient size, places it in the jaws of the microtome properly oriented, sections it, fixes a few sections to the glass slip with ether and alcohol, and the preparation is then handed to the student, or the student may do the sectioning for himself. Stains and after treatment may be used at discretion, and when the preparation is ready for observation and study the student has a permanent one which can be of use afterwards for reference or for demonstrations. I have large quantities of material stored in this way in collodion, some of which has been in this condition for over two years, and the sections this year show that it is in as good condition apparently as when first prepared. In order to show how far the method may be extended with success I will give here a list of the things imbedded in collodion which I have stored in greater or lesser quantity now in the laboratory, usually a sufficient amount to last for from five to ten years, and in some cases for a longer period.

Fungi.—Olpidiopsis saprolegniæ, Synchitrium decipiens, Empusa grylli, Cystopus candidus, Peronospora alsinearum (conidial stage, oogonia, and oospores), P. parasitica (same), P. effusa, Plasmopara obducens, P. halstedii, P. geranii, Ustilago zeæ, Doassansia opaca, D. martinoffiana, Pilacre petersii (from dried material), Crucibulum vulgare, Cyathus striatus, Collybia radicata, Coprinus micaceus, C. atramentarius, Puccinia pimpinellæ (three stages), Puccinia podophylli (two stages), P. asteris, P. orbicula, P. anemones-virginianæ, P. xanthii, P. circææ, P. peckiana (caeoma and spermagonial stage), Uromyces caladii, Phragmidium gracilis (aecidial stage), Phragmidium sp. (aecidial stage), Gymnosporangium macropus, Roestelia on Amelanchier fruit, Melampsora farinosa, Aecidium clematidis, Ae. sambuci, Ae. impatientis, Ae. compositarum, Ae. grossulariae, Ae. podophylli, Magnusiella potentillae, Morchella conica, Discina warneri, Herpotrichia keitii, Xylaria polymorpha, Entomosporium maculatum.

Algæ.—Fucus vesiculosus, Laminaria saccharina, Leathesia difformis, Mesogloea divaricata, Nemalion multifidum, Dasya elegans, Chondriopsis tenuissima, Champia parvula, Rhabdonia tenera, Gracillaria multipartita. All the species are in fruit, and the two latter with both tetraspores and cystocarps; cystocarps in the other Florideæ.

Bryophytes.—Antheridia and archegonia and development of the sporogonium in Marchantia polymorpha, Conocephalus conicus, Preissia commutata. Antheridia and archegonia in Pellia endiviaefolia, Pallavicinia lyellii. Development of sporogonium in Aneura sp., Ptilidium ciliare, Cephalozia curvifolia, C. multiflora, Lophocolea heterophylla. Antheridia and archegonia of Mnium affine and cuspidatum.

Ferns.—Sporangia of Pteris albolineata, Aspidium falcatum, Onoclea struthiopteris.

Living material of the ferns is kept in the green houses for complete studies of development, and here the students have practice in methods by carrying the material through all stages of preparation. The same thing is done by them in other groups also. Quantities of other material fixed in various ways are kept at hand in alcohol. Material imbedded in paraffin has not been kept a sufficiently long time to determine the value of this method in the storage of material ready for sectioning, but it may be kept in cedar oil ready for infiltration.—GEO. F. ATKINSON, *Cornell University.*

EDITORIALS.

Is the Phyton a Concept of any Value?

IN THE PREFACE to the second edition of his *Survival of the unlike,* Professor L. H. Bailey explains his adoption of the idea of the phyton as a unit of plant structure and function, to which in a review of the first edition[1] we took exception, asking whether the idea of the shoot would not answer the purpose better, since the variations to which he called attention existed not so much in the successive phytons as in the shoot taken as a whole. We quote his words of reply in order to examine further his conception of the phyton:

> It is by no means essential to the conception of the phyton that the different phytons upon any branch shall be unlike; although it should be remembered that, as a matter of fact, no two branches on a plant are alike, and yet every branch springs from a phyton. The point is that any phyton is capable of making a new plant, and the characters of that new plant will be very markedly determined by the conditions under which it grows. The phyton is simply the unit of asexual propagation as the seed is of sexual propagation. (See the contrasts of the *Keime* and the *Knospen* in Möbius' recent *Beiträge zur Lehre von der Fortpflanzung der Gewächse.*)
>
> The word bud might be substituted for phyton, but that word now has two or three technical uses; and, moreover, it is not always necessary that actual buds be present in order that phytons shall grow when made into cuttings or grafts. Potentially, every node and internode of the plant is an individual, for it possesses the power, when removed and properly cared for, of expanding into what we call a plant, and of perfecting flowers and seeds and of multiplying its kind (p. 83).

THE HISTORY of the theory of the phyton is that of every other discarded theory. Its form is first modified; then it is remodeled again and again in the hope of making it fit the facts better, until finally it is apparent that it must be entirely abandoned for something better. Gaudichaud brought the phyton into prominence, basing the theory upon the anatomical vagaries of Wolff and Du Petit Thouars. But a fuller knowledge of anatomy through the researches of von Mohl led to the general abandonment of the concept in the form in which he advocated it. Dr. Gray adopted the idea in a modified form, retaining the term phyton, and was the first to introduce it authoritatively into American botanical literature through his *Botanical Text-book*. In his *Structural Botany*, as late as 1879, he affirms that "this theoretical conception of the organic composition of the plant is practically important to the correct understanding of morphological botany." From this source probably most of us of this generation derived the idea and believed it to be of value.

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[1] BOT. GAZ. **22**: 501. D. 1896.

It should be observed that the phyton or phytomer of Gray was a single node and internode with its leaf or leaves. No account whatever was taken of the root, which was looked upon as, normally, a mere appendage of the lowest phyton, the like of which other phytons were capable of producing. It is scarcely necessary to say that no one who now considers the origin of the primary root can look upon it as morphologically an outgrowth of the shoot, and Gray's phyton has been abandoned just as Gaudichaud's was.

PROFESSOR BAILEY has felt it necessary to remodel the definition yet again. To him it is "that asexual portion of any plant which is capable of reproducing itself."[2] Now no one is more familiar than Professor Bailey with the multifarious ways in which plants are propagated by the gardener, and we must understand from these words that a leaf-fragment of begonia or a root-cutting of an aspen constitute a phyton. Surely in no possible sense can these be considered as morphologically equivalent parts. Thus, beginning as an anatomical concept, the phyton has lost even an appearance of morphological significance. Let us then examine it as a physiological concept in the light of Professor Bailey's explanations.

In the preface already quoted, he says: "the phyton is simply the unit of asexual propagation as the seed is of sexual propagation." This mystifies us, though we have not failed to consider Möbius' contrast between *Keime* and *Knospen*, as admonished (*Post*, p. 385). The only viable structure that one finds in the seed is the embryo, usually with a well developed shoot consisting of a stem with a leaf or leaves, and a root. Yet we must understand that this embryo is not a phyton in Professor Bailey's sense, though it "reproduces" itself precisely as a cutting would!

And, finally, we are told that, were it not for its various meanings, "the word bud might be substituted for phyton." (Now as a bud is merely an undeveloped shoot, it would seem that this is not far from

[2] Survival of the unlike 84.

the suggestion originally made in the review.) Such groping after the shadowy phyton is not only hopeless but useless. If, potentially, every node and internode of a plant is an individual, for the reason which Professor Bailey assigns, so is every fragment which contains a growing point or is capable of forming one when injured. How large the "individual" will be depends solely upon the necessities of nutrition. What a curious sort of *indivisibility* this is!

The attempt to find a unit of individuality in the phyton has utterly failed, and the whole fancy may well be abandoned. We shall then be rid of at least one technical term which is no longer needed to express an idea. Professor Bailey's well grounded point as to the overmastering influence of external conditions upon the form of members can be quite as adequately expressed in terms of modern anatomy.

CURRENT LITERATURE.

BOOK REVIEWS.

A handbook of microscopical technique.

THE mere announcement of the issue of a third edition of Strasburger's *Das botanische Practicum* is sufficient to insure the orders of every student and botanical laboratory giving any attention to histology. The work is already so well and so favorably known that it needs no commendation at our hands. We therefore undertake only to point out the general character of the changes in the present edition[1] which are calculated to fit it still better to serve the purpose of a guide to microscopical technique as applied to plants.

The last edition was published in 1887. In the ten years which have since elapsed important advances have been made in technique. Notable among these are the introduction of apochromatic lenses for all the higher powers of the microscope, the extensive adoption of fixing, staining, and imbedding methods, and the universal use of the microtome for section cutting. In the matter of fixing and staining the tendency has been to the perfecting of a few processes, rather than to the increase in the number of materials. This has largely been due to the criticism of technique following upon the necessity of determining whether or not observers were dealing with real structures or with appearances which they had themselves created by their technique.

Professor Strasburger has not found it possible to make use of all the extensive microtechnical literature without completely changing the character of the book. He has preferred to keep the old form, though with much altered contents, and we feel sure that those who need to consult the book will be rather glad that he has been limited in this way. Too much information is sometimes as embarrassing as too little.

The most striking change which meets the eye is the great extension of the introduction. In this part the author has now brought together directions for the use of the microscope and various accessories which before were scattered through several chapters, besides the necessary instructions as to imbedding processes, the use of the microtome and the care of knives. This expands the introduction from 11 to 66 pages.

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[1] EDUARD STRASBURGER: Das botanische Practicum. Anleitung zum Selbststudium der mikroskopischen Botanik. Für Anfanger und Geübtere. Zugleich ein Handbuch der mikroskopischen Technik. Third edition. 8vo. pp. xlviii + 740; figs. 221. Jena: Gustav Fischer, 1897. Price, unbound, *M* 20; bound, *M* 22.

Another improvement consists in placing at the head of each chapter a list of the materials needed for the task which follows. Besides this indication of the contents of each chapter there is in the table of contents a full analysis of it so that anything is readily found. Besides this, in the voluminous indexes, upon which unusual care is bestowed, every point is completely covered. These indexes extend to 109 pages. The only improvement that could be made would be to combine them into one. A single index is more readily used than six. An exception should be made of the second, which is not really an index, but gives a list of plants used, arranged according to the time at which they should be collected.

The number of figures has been increased from 193 to 221; but the number of plants treated has been decreased in order to make room for the introduction of new technique without unduly increasing the size of the book. At first sight this seems to have been done, but the number of pages is only greater by 66 than in the second edition. The apparent increase is chiefly due to thicker paper.

The third edition is fitted by the many important changes in text, as well as these more superficial ones, to maintain the reputation which its predecessors have won, and students are under a new debt of gratitude to this indefatigable author, who takes time to put at the disposal of both beginners and investigators his great experience and encyclopedic knowledge.—C. R. B.

Index to Saccardo's Sylloge.

The eleven thick royal octavo volumes containing descriptions of all fungi known before 1895 form a monumental work; and to the author, Professor P. A. Saccardo of Padua, Italy, all mycologists are under the greatest obligation. The publication of the work began in 1882 and was brought to a successful close in 1895, the several volumes succeeding one another at surprisingly short intervals, considering the vast amount of labor involved. The author is now increasing the value of the work for ready reference by issuing a comprehensive index,[2] forming the twelfth and final volume. It gives all the genera in a single alphabetical list, with species, varieties, etc., under each genus, and also the hosts and the geographical distribution. The general arrangement and the typographical execution are excellent. A better index could not well be devised. The first part now issued extends as far as *Puccinia Pyrolæ*, showing that it probably includes fully half the volume. It is, however, entirely unaccompanied by information regarding subsequent publication, there being no preface, outline, introduction, or explanatory note. But every part of this index is of greatest service to those who have occasion to consult the work, and we are grateful to have the use of the first part while the second is in preparation.—J. C. A.

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[2] SACCARDO, P. A.—Sylloge fungorum omnium huiusque cognitorum. Vol. 12. Index universalis et locupletissimus generum, specierum, subspecierum, varietatum hospitumque in toto opere expositorum. Pars 1. Roy. 8vo. pp. 640. Berolini, Fratres Borntraeger, 1896. 40 francs.

An introduction to horticulture.

The arrangement into a clear and well-defined science of the principles which underlie an old and empirically developed art is a matter of slow growth. Horticulture boasts of being the oldest of human arts, and yet the science of horticulture is ill defined and without adequate representation in logical form. Especially since the establishment of colleges for the teaching of agriculture and allied subjects a concise text-book to serve as a basis for horticultural teaching has been a genuine desideratum.

A work that appears in many ways to possess the right qualities for meeting in part these demands has recently been put forth by Professor Emmet S. Goff[3] of the University of Wisconsin. The work is the outgrowth of the author's long experience in teaching horticulture, supplemented by especially successful labors as an experimental horticulturist.

In contrast with the usual method of writing a general treatise and subsequently condensing an introductory work from it, the author has first prepared the elementary text. The work is designed for students in first-year college work, having little or no previous instruction in chemistry, physics, or botany. The work opens with a dozen pages of fundamental matters, clearly and succinctly stated. The remainder of the work is divided into four parts: *a*, the round of plant life from germination to the production of seed, with many details of structure and physiological action; *b*, the plant as affected by unfavorable environment, such as extremes of temperature, light, water, food, etc., embracing a variety of ecological observations of great interest to the cultivator; *c*, plant manipulation, especially propagation by seeds and division, transplanting and pruning; and *d*, plant breeding. In an appendix is given an outline for a course of sixty or more laboratory experiments to practically illustrate the text.

The work is written in a lucid and crisp style, well paragraphed for class use, and throughout imparts the feeling of a strictly scientific treatment, always apropos, however, of work-a-day application.

There is little in the book that invites adverse criticism. The only matter worth mentioning is the use of the term assimilation. It is made to cover the formation of plant food by chlorophyll bodies, a time-honored usage, but wholly erroneous and indefensible. Curiously enough, the same sentence which defines the author's use of the term includes a statement of assimilation in the really proper sense: use of the food "by the protoplasm in making new parts and in repairing waste." One cannot but wonder how long a time must elapse before the three independent processes in plants — the chlorophyllous production of food, digestion, and assimilation — will be generally apprehended to an extent that will insure their correct presentation in works that purport to be botanically accurate.

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[3] GOFF, E. S.— Principles of plant culture: an elementary treatise designed as a text-book for beginners in agriculture and horticulture. Madison, 1897. Published by the author. 12mo, pp. 276. 173 illustrations.

To offset the misusage just referred to, although making it the more inexplicable, one can heartily commend the careful employment of the terms fecundation and pollination, in place of the much-abused term, fertilization, which is often made to do service for both processes without distinction. In general the book is to be praised on account of the careful balance preserved between the various divisions of the subject, for the logical method of presentation throughout, and for the serviceable illustrations, two-thirds of which are original.

Some regret must be felt that the work has been arranged for such an elementary grade of instruction. Yet having performed the more difficult task of writing an acceptable work for beginners, it is to be hoped that the author will follow it with a general treatise suitable for more advanced students.—J. C. A.

Plant diseases.

Another general work is now available to the student of plant diseases. An English edition of Dr. von Tubeuf's book, issued in Germany in 1895, which treats of those diseases of plants induced by cryptogamic parasites, has been prepared by his former pupil, Dr. Wm. G. Smith[4] of Edinburgh. The English edition is printed on extra thick paper, which makes the work uncomfortably heavy, considering the amount of matter it contains, but has the one merit of displaying to good advantage the numerous half tone engravings from the author's excellent photographs. The work is well printed. The translation is in general acceptable, although one must take exception to the indefensible and unscientific use of the word "fungoid" for fungous, an error that can only be forgiven in unlearned writers.

One hundred pages of the work are given over to the nature and effects of parasitism, with some account of the extent of parasitic diseases and means for combating them. The remaining five-sixths of the work are devoted to a systematic account of the fungi, bacteria, myxomycetes, and algæ that cause diseases. The English edition is brought down to date, by the addition of much new matter.

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[4] TUBEUF, DR. KARL FREIHERR VON.—Diseases of plants induced by cryptogamic parasites: introduction to the study of pathogenic fungi, slime-fungi, bacteria and algæ. English edition by William G. Smith. Longmans, Green & Co., London, New York and Bombay, 1897. 8vo. pp. 598. 330 illustrations. $5.50.

The results of American research are prominent throughout the book, both in regard to the occurrence of special diseases and parasites, and also in regard to treatment for the same; yet the suggestions for use of fungicides and other preventive measures will seem meager and inadequate to American students. The translator has indicated the species found in Britain and North America, and has added many valuable notes.

The work is perspicuously written, accurate, reasonably complete, and altogether the best work giving a systematic review of cryptogamic parasites and the diseases they induce in plants, yet published in the English language. —J. C. A.

Report of the New York State Botanist.

It has been thirty years since Mr. Charles H. Peck became State Botanist of New York. In this time twenty-eight annual reports have been printed. With exception of the last one all have been octavo in size, and have borne much similarity in appearance.

About half of them have been accompanied with plates. The intricate official system of transmitting and publishing these reports has often delayed their appearance beyond all reasonable limits. Once the work was seriously checked by failure of the state to provide the necessary funds, and several of the reports have been printed in extremely small editions. In spite of the derelictions of those who receive and issue the reports, or rather of the system under which they are issued, the work of studying the state flora has gone steadily on, and a feeling of permanency and uniformity has become established.

The recent receipt of the last report issued,[5] that for 1894, brings an agreeable surprise. The size of page has been increased to a quarto (24×30$^{\mathrm{cm}}$), the paper and typography are better, colored plates are used, and the work is attractively bound in cloth. It is a volume in keeping with the dignity of the state and with the importance of the subject, and ought to be the model for subsequent reports.

The subject matter is distributed essentially as in preceding reports. The plants new to the state include eleven species of fungi new to science. Of species previously reported from the state four new varieties are described, all fungi. The carices of the state have been collected and especially written up for this report by Dr. E. C. Howe. There are 133 species described with many valuable notes. Dr. Howe is mentioned in the first report made by the present state botanist in acknowledgment of his contributions and interest in the state flora, and such a piece of work as the present one is necessarily replete with the results of long familiarity with the local flora.

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[5] PECK, CHARLES H.—Annual report of the state botanist of the state of New York, made to the regents of the university. 4to. 241 pp. 44 col. pl. Albany, James B. Lyon, state printer, 1896.

The special feature of this report is the article on the subject of edible fungi. It has been known for a long time that the author was accumulating colored drawings and mycophagic notes pertaining to the food fungi of the state, and a special monograph on the subject has been expected. The difficulty of securing its independent publication has led to its incorporation in the annual report. Mr. Peck gives most valuable assistance and suggestions regarding the collection and use of this highly nutritious and palatable food, founded upon personal experience and ripe knowledge. Sixty-three edible species and four harmful ones are described and figured. The forty-four colored plates, with figures of the fungi natural size, add greatly to the value of the report. The lithographic work, although it cost the state over $3000, falls somewhat short of being entirely satisfactory. Only twice before, in 1869 and 1870, have the botanist's annual reports been supplemented with colored plates, and they were then somewhat better executed than are the present ones.

It has always been a source of regret that the state makes no provision for the sale of public documents of this character. Such a valuable publication ought to be obtainable by everyone who chooses to pay a reasonable price for it. Now that the general government has set a commendable example of offering scientific and other documents for sale at nominal prices, it is hoped that the states will adopt a similar method, and thereby greatly increase the permanent usefulness of the scientific work which they foster.—J. C. A.

The reproduction of plants.

In 1891 and 1892 Professor M. Möbius published in the *Biologisches Centralblatt* two papers on the effect of continuous vegetative propagation and the conditions on which blooming depends. Last year he contributed one on the development and significance of sexual reproduction in the plant kingdom. He has brought these papers together and added such other discussion as seemed necessary "to place the phenomena of reproduction in the right light in relation to other vital phenomena, and, at the same time, to distinguish correctly in conformity therewith the different sorts of reproduction in plants." The result is a volume of five chapters and something over 200 pages.[6]

In the introduction the two kinds of reproduction are defined and characterized. These are reproduction by buds (Knospen) and by germs (Keime). Instead of distinguishing reproduction into sexual and non-sexual methods, the author's point is that the real distinction lies in the rejuvenation of the cell or cells in the case of germs and the absence of any such change in the case of buds. "Spores and seeds," he says, "are germs in the sense that in their production rejuvenation of a cell has taken place; that the former have arisen in a purely asexual manner and the latter have arisen by fertilization is a secondary difference which is without significance for multiplication." In contrast to this "in multiplication by buds no rejuvenation occurs, but only a growth by ordinary cell division."

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[6] MÖBIUS, M.—Beiträge zur Lehre von der Fortpflanzung der Gewächse. 8vo. pp. viii + 212. figs. 36. Gustav Fischer: Jena. 1897. *M* 4.50.

In the second chapter Möbius undertakes to show that the idea that plants continuously propagated by cuttings, offsets, tubers, etc., become weakened and are more liable to epidemic diseases, has no basis in fact. In combating this idea he brings together many interesting facts regarding both wild and cultivated plants which are propagated vegetatively.

The third chapter, "on the conditions upon which the blooming of plants depends," is a presentation of the relations of the age of the whole organism or of certain shoots, light, temperature, moisture, etc., to blooming. The fourth chapter discusses the relation between germ and bud reproduction for the purpose of showing that in most cases vegetative reproduction is not the primary method but one into which plants have been forced when external conditions have repeatedly prevented the formation of flowers or fruit.

In the last chapter the author shows the steps in the evolution of sexuality among the algæ, and finds the significance of sexuality in the opportunity it gives through crossing for the origination of new species and for the production of more complex forms; *i. e.*, to put it as usual, sexual reproduction is a prolific source of variation.

The thesis of the book to which other ideas are subsidiary is that the distinction between the modes of reproduction is to be found in the rejuvenation of the reproductive cell in one case and its absence in another. This seems a very tenuous thread on which to string so many important phenomena. That rejuvenation does occur in many cases is readily seen; that it occurs in the spores of fungi has been proved in only a few cases, and that doubtfully; the rest is assumption. Moreover, since all such distinctions are merely classificatory conveniences in the arrangement of observed facts, it strikes us that there is little value in making the thread so fine as to be grasped with difficulty when we wish to add a new pearl to the strand. Copulation of gametes is an easily observed phenomenon and will serve pedagogical purposes much better than the new proposition. Thus we may clearly distinguish sexual and non-sexual reproduction in the thallophytes, among which it is not worth while to attempt to distinguish non-sexual from vegetative reproduction. That becomes important only in bryophytes and higher plants, among which it is readily done by applying the term non-sexual to reproduction (here by spores) which gives rise to the alternate phase in the life cycle (the gametophyte), and the term vegetative to those methods which produce the same phase again.

Furthermore, a classification which brings together seeds and spores, as the proposed scheme does under the term *Keime*, will be as prolific of misconception as their frequent comparison has ever been.

We become early suspicious of the book when we find the author postulating a species as an entity. How can anyone who has studied plants write such a sentence as this: "Nun aber ist der Natur nur an der Erhaltung der Species gelegen und die Individuen dienen nur um die Idee der Species in der Welt der Erscheinungen zu repräsentiren!" Much confusion of ideas appears in the frequent comparisons drawn between the gametophytes of the lower plants and the sporophytes of the higher; even the "flowers" of mosses and the flowers of seed plants are compared! Among other curiosities we find definition of an individual: ". . . . ein Körper, der sich nicht theilen lässt und zwar so, dass die Theilung unmittelbar zwei oder mehrere neue vollständige Körper ergibt." How would Möbius apply this to such a plant as Caulerpa? Or to almost any thallophyte for that matter?

The impression that the book leaves is that the author has endeavored to assimilate modern ideas of morphology without complete success; that these ideas have opened out to him visions of possible coordination of facts which he has not yet thought through to their logical outcome; and that he has allowed obsolete views of the relations of the flowering plants to the lower ones to distort his newer conceptions. Among the latter there are some of value, but they are not new nor are they presented with sufficient clearness to make the book one of any real importance.—C. R. B.

NOTES FOR STUDENTS.

KLEBAHN has continued his studies on zygotes with the investigation of the auxospore formation in a diatom, *Rhopalodia gibba* O. Müller.[7] In this species the process involves an undoubted sexual act in the copulation of gametes of separate origins. The mother cells of the gametes are very commonly of unequal size. They become attached to each other side by side, and the nucleus of each divides first into two and then into four daughter nuclei, of which two remain small. Each mother cell then divides by constriction transversely in such a way that the daughter cells each contain two nuclei, one large, the other small. These daughter cells are the gametes, and they fuse in pairs, one gamete of each fusing pair being derived from each of the two mother cells. The small nuclei have generally disappeared during fusion. The so formed zygotes then grow out at right angles to the long axes of the mother cells and form auxospores. The large nuclei fuse quite late in the development of the auxospore. The process of conjugation here also, as in the desmids Closterium and Cosmarium, involves the formation of supernumerary nuclei, but these are formed in the diatom before conjugation instead of after as in the desmids. The resemblance of the process in Rhopalodia to the formation of supernumerary nuclei in copulating infusorians, and to the formation of polar bodies in animal eggs is quite close. The author is also of the opinion that twice as many chromosomes appear in ordinary vegetative divisions as in the two ripening divisions, and that just before the latter a reduction in the number of chromosomes may occur. The smallness of the nuclei, however, and the few cases where mitosis was observed, leave this question in doubt.—R. A. H.

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[7] "Beiträge zur Kenntniss der Auxosporenbildung, I. *Rhopalodia gibba* (Ehrenb.) O. Müller." Jahrb. für wiss. Bot. **29**: Heft 4. 1896.

IN THE *Berichte der deutschen pharmaceutischen Gesellschaft* for the current year (p. 11) there appears a short paper by Carl Müller of Berlin concerning the inclusions in the living cell wall. He announces the discovery in the wall of certain cells in the root of *Spiræa filipendula* of crystal like masses which gave none of the reactions of calcium oxalate or calcium carbonate, but on the contrary all those of cellulose. He concludes, therefore, that these crystalline masses are cellulose, and thinks that their occurrence is very general.—L. S. C.

UNDER the title of *Sclerotinia heteroica*[8] M. Woronin and S. Nawaschin give the completed account of their discovery of a heterœcious ascomycete. The two forms in which the fungus appears are the saucer shaped long stalked apothecium, which develops from a sclerotium enclosed in a mummified fruit of *Ledum palustre*, and the conidial form whose mycelium develops in leaves and twigs of *Vaccinium uliginosum*. The ascus fruit had been already described by Nawaschin, as *S. ledi*.[9] The conidial fruit was first obtained in cultures on nutrient gelatine and its discovery in this way led to the supposition that it might occur in nature on leaves of the same host plant as is the case with *Sclerotinia megalospora*, whose conidia and apothecia are both parasitic on *Vaccinium uliginosum*. No conidial form, however, could be found on Ledum, but the discovery was made that what has previously been known as the conidial fruit of *S. megalospora* consists really of two forms widely distinct from each other; one of which, as was proved by artificial infections, is able to produce sclerotia only in the ovaries of the Vaccinium; while the other can infect only those of Ledum. The two conidial forms differ further in the size of their spores, in their effect on the host plant, in their manner of germinating in water, and especially in their manner of penetrating to the ovary of the host plant. Infection in both cases takes place through the stigma at the time of pollination. In *S. megalospora* each conidium produces a germ tube which grows independently down through the style to develop the mycelium in the ovary, while in *S. heteroica* the germ tubes of a number of conidia fuse to form a single much stronger hypha, which then penetrates downward through the style. This anastomosing of germ tubes has also been observed by the authors in *S. padi* and *S. aucupariae*, and furnishes a further interesting example of a fusion of protoplasmic masses which cannot be regarded as having a sexual significance in the ordinary sense. The life history of *S. heteroica* is as follows: The capsules of Ledum are infected through the stigma. The mycelium forms in the ovary a sclerotium which germinates and forms a single stalked ascus fruit in the following May. The ascospores are carried by the wind to the unfolding leaves of *Vaccinium uliginosum*, in which they develop a mycelium which produces the pustules of conidiospores a few weeks later.

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[8] Zeitschrift für Pflanzenkrankheiten—:—. 1896. [Heft 3–4. *pl.* 3, 4.]

[9] Über eine neue *Sclerotinia* vergleichen mit *S. rhododendri* Fischer. Berichte d. deutsch. bot. Ges. **12**:—. 1894. [Heft. 5.]

Heteroecism has so far been observed only in the Uredineæ, and its discovery among the ascomycetes is of great interest, as suggesting that various *fungi imperfecti* may be connected with ascocarpous forms in this way.—R. A. H.

THE PRELIMINARY NOTICES concerning the structure and cytology of the Mucorineæ by MM. Léger and Dangéard, which have appeared in *Comptes Rendus* and in *Le Botaniste* during the past few years, have been followed by the extended paper of the former author,[10] in which he describes at considerable length the phenomena observed, and illustrates the same by twenty-one photo-process plates. The cytology, development of the sporangia, conidia, zygospores, etc., were studied in the following genera: Sporodinia, one species; Rhizopus, one species; Mucor, four species; Chaetocladium, two species; Thamnidium, one species; Pilobolus, two species; Pilaria, one species; Mortierella, two species; Syncephalis, one species; Pitocephalis, one species; and were found to be strikingly uniform throughout the series of forms investigated. The nuclei, which the author found most readily demonstrated by the use of Bohmer's hæmatoxylin acidulated with acetic acid and allowed to act for from one to five days, are present in the hyphæ in great abundance, are variable in size (.5–5μ in diameter), having a central deeply staining nucleolus surrounded by a peripheral layer which does not stain, the whole enclosed in a nuclear sac. The vegetative nuclei always divide directly, mitotic divisions only occurring in the spores at the period of germination. The conidia result from the more or less simultaneous separation of the contents of the sporangia into polygonal masses, separated from one another by a layer of intersporal non-granular protoplasm which ultimately forms the matrix in which the mature spores are imbedded. Each polygonal mass contains several nuclei, and after surrounding itself with a wall becomes a spore. According to the author the process of spore formation in the Cephalideæ corresponds in all respects to that in forms characterized by sporangia of the ordinary type, and the homology between the spore rows of this section of the mucors and typical sporangia, which was first maintained by Van Tieghem in his well known memoirs, is thus considered to be fully substantiated.

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[10] LÉGER, MAURICE, Recherches sur la structure des Mucorinées. Pp. 1–150. 21 plates. Poitiers, E. Druinaud. 1896.

The most important portion of the paper is that which deals with the nuclear history of the process of conjugation, which was studied in a limited number of the species mentioned, and the subsequent history of the zygospore up to the time of its germination. The young zygospore is said to contain sometimes thousands of nuclei derived from each gamete, and as the spore matures these nuclei gradually disappear. As soon as the last have disappeared two groups of bodies make their appearance at each end of the spore. These bodies, to which the author gives the name "embryogenic bodies," appear to be derived from the nuclei which have disappeared; though they are not formed nuclei, consisting of naked masses of protoplasm, doubtless nuclear in its nature. The embryogenic bodies later fuse in each group. The two resultant masses, which thus replace the groups, are called embryogenic spheres, and having surrounded themselves with two distinct walls constitute the "spheres embryonaires" of the mature zygospore. When the spore is about to germinate these spheres lose their walls, unite to form a single central mass in which numerous nuclei then make their appearance, which, after a single mitotic division, pass out into the hypha of germination. In the formation of the azygospores the history is exactly the same except that there is but one group of embryogenic bodies, and consequently but one embryonic sphere in the mature spore. The author considers the union of the embryogenic bodies as representing a sexual union, and for this reason holds that the azygospores are as truly sexual spores as the zygospores themselves. The phenomenon of conjugation is thus held to be a matter of secondary importance and not sexually significant in the group. To one who is not inclined to attribute sexual significance to all nuclear fusions the question naturally occurs in this connection whether the final union of the embryonic spheres may not represent a sexual union rather than that of the embryogenic bodies, the nuclear material of which may perhaps have been derived in either group from the same gamete; the delay in the fusion of the former finding a parallel in the nuclear history of the zygospore of Basidiobolus.

It may be mentioned that of the forms investigated in the paper two species of the genus Mucor are described as new; one *M. rigidus* being closely allied to *M. mucedo*, while the other, *M. rubescens*, is remarkable for the bright red color of its sporangia.—R. T.

MR. EDWARD C. JEFFREY, of the University of Toronto, makes some preliminary announcements[11] in respect to the prothallus of *Botrychium Virginianum* that are of interest. He has been fortunate enough to obtain several hundred specimens in various stages of development, and thinks that he can soon fill in the gaps in our knowledge of the life history of this plant. The full account of the development of the gametophyte is to appear shortly in the Transactions of the Canadian Institute.

The largest prothalli were 18^{mm} long. They are monoecious, the antheridia being found upon well defined median ridges, and the archegonia upon their sloping sides. An abundant endophytic fungus, similar to a sterile Pythium, is common in the oil bearing tissue on the ventral side of the prothallus. It makes its way from the prothallus to the exterior through the root hairs.

Mr. Jeffrey confirms Campbell's account of the endogenous structure of the antheridia. A superficial cell divides by a periclinal wall into an outer and an inner cell. The latter gives rise to a mass of spermatozoid mother cells. The spermatozoids are of the usual fern type, spiral in form and remarkably large. The archegonium has a long neck made up of four tiers of cells, and projects above the surface of the prothallus. There are points in its development and internal structure that remind one of Marattia.

The oospore divides into octants after the usual manner, but Mr. Jeffrey has been unable to derive the root, stem and first leaf ("cotyledon") from definite octants. The "cotyledon" appears above ground the first year, and after that one leaf is put forth each season. Prothalli have been found attached to six year old sporophytes, which illustrates the great longevity of the gametophyte. It is not unusual to find two sporophytes attached to a single prothallus.— B. M. D.

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[11] JEFFREY, E. C. The gametophyte of *Botrychium Virginianum*. Proc. Canadian Institute, 1896.

NEWS.

OUR ASSOCIATE, Dr. Fritz Noll, has been promoted to an assistant professorship in the University of Bonn.

M. GEORGES VILLE, Professor of Vegetable Physiology at the Museum (Paris), died February 22, aged 63 years.

PROFESSOR TEODORO CARUEL has retired by his own desire from the active duties of the professorship of botany in the University of Florence.

M. GASTON BONNIER, Professor of Botany at the Sorbonne, has been elected member of the Academy of Sciences in place of the late Mr. Trécul.

DR. C. VON ETTINGSHAUSEN, Professor of Botany at the University of Graz, well known for his paleobotanical work, died February 1, aged 61 years.

PROFESSOR CONWAY MACMILLAN has published "Notes for teachers on the geographical distribution of plants" in the first number of *Journal of School Geography.*

DR. L. JURÁNYI, professor of botany and director of the botanic garden and institute of the Royal University of Hungary, died at Abbazia on February 27, in the sixtieth year of his age.

A GOLD MEDAL has been bestowed on Professor Jakob Eriksson of Stockholm by the Royal Swedish College of Agriculture in recognition of his studies into the life history of grain rusts.

MR. E. P. SHELDON, formerly connected with the University of Minnesota, has undertaken the exploration of the Blue mountains of Oregon, under a commission from the National Herbarium.

THE GERMAN GOVERNMENT is asked to appropriate two million dollars for the establishment of the Botanical Garden of the University of Berlin and its Museum, and the pharmaceutical laboratory.

AT THE MEETING of the Academy of Science of St. Louis, held on the evening of April 5, Mr. H. C. Irish presented a paper on the relations of the unfolding of plants in spring to meteorological conditions, in which were embodied deductions drawn from a series of observations made at the Missouri Botanical Garden, and those by other observers, extending back to the time of Stillingfleet, in the last century.

Dr. Edson S. Bastin, Professor of Materia Medica and Botany at the Philadelphia College of Pharmacy, died recently at the age of 54. He is best known to botanists as the author of *Elements of Botany* and *College Botany*.

Dr. E. B. Copeland has been appointed assistant professor of botany in the University of Indiana, *vice* Dr. Geo. J. Peirce, who resigned to accept a similar position, in charge of plant physiology in Leland Stanford Junior University.

The Michigan Wild Flower Co. of Rochester, Mich., lists about 750 species of native plants which can be supplied in such quantities as may be desired. Their offer will be serviceable to those who wish to obtain native plants in good growing condition for experimental or illustrative purposes.

Alexander suggests[1] a trick for preserving a celloidin block from which the cutting of a series of sections is proceeding, in case the cutting has to be interrupted. Heretofore it has been necessary to remove the block and place it in alcohol. In this way several sections are apt to be lost, as it is impossible to replace it in the microtome in the exact plane occupied before. Alexander slips over the block a glass tube which fits [illegible] and into which alcohol is poured. The tube may then be closed with a cork.

Dr. Joseph F. James died at Hingham, Mass., March 29, at the age of forty. His numerous botanical writings have appeared in various journals. For nearly twelve years he was an instructor in botany in Cincinnati College of Pharmacy, Miami University, and Maryland Agricultural College. He was also in government employ in various positions, in connection with the Division of Vegetable Physiology and Pathology, and with the United States Geological Survey. His writings show him to have been a painstaking student, especially given to bibliographical work.

A letter from Mr. John C. Willis, director of the Royal Botanic Gardens at Peradeniya, Ceylon, expresses his desire that American botanists will avail themselves of the opportunities which he is able to give them. Ceylon is virgin territory for most botanical work, and has the advantage of having a thoroughly good "Flora" (Trimen's) already written. Mr. Willis reports a greater variety of climate than most tropical regions, and therefore a great variety of plants. The island is beautiful, traveling is easy, living fairly cheap, and Colombo has lines of steamers from all quarters.

Professor Conway MacMillan sails June 9 on the Germanic from New York to Liverpool. He will spend some time abroad, having been specially commissioned by the regents of the University of Minnesota to prosecute investigations in the old world capitals. During his absence the

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[1] Zeitschrift f. wiss. Mikroskopie 13:—. Cf. Bot. Cent.

Department of Botany will be in charge of Mr. Francis Ramaley from June 1 to September 1, and thereafter in charge of Assistant Professor D. T. MacDougal until Professor MacMillan's return. Professor MacMillan's London address will be 40 Bedford Place, Bloomsberry Sq., W. C.

THE SPRING NUMBER of the *Fern Bulletin* contains sixteen pages of interesting matter for fern lovers. C. E. Waters writes regarding *Asplenium Bradleyi* and its occurrence along the Patapsco river near Baltimore, Md. Geo. E. Davenport records the stocking of a natural fernery during the last twenty years by means of spores brought by the wind from considerable distances. A. A. Eaton describes a new quillwort under the name of *Isoetes Montezumæ*. It was collected by C. G. Pringle in Mexico. C. F. Saunders writes about *Asplenium montanum*, and L. M. Underwood calls attention to the desirability of collectors securing ample notes and specimens of the various forms of *Botrychium ternatum* to aid in determining relationship. There are other articles in the number, and also three excellent illustrations.

THE LLOYD distribution of photogravures of fungi has recently been extended to nos. 15 and 16. The first is a very perfect plate of a number of specimens of *Lycoperdon gemmatum* Batsch, and the last gives a mass of *Clavaria stricta* Pers, and also of *C. coronata* Schw. The high standard of the work is maintained.

Mr. Lloyd has also printed a second statement of the condition of his recently projected mycological museum, covering the years 1895 and 1896, practically the whole time of active growth. On the first of January 1897 the museum contained 1431 specimens, representing 760 species of fleshy or woody fungi. The soft forms are preserved in alcohol. Formalin has been tried but with poor results in most cases. Contributions to this collection, which is accessible to all visitors, will be gratefully acknowledged.

THE THIRD ANNUAL MEETING of the Michigan Academy of Science was held at Ann Arbor March 31 to April 2. In the section of botany, over which Professor F. C. Newcombe presided, the following papers were presented: Comments on the nature of the work suited to a botanical club of an agricultural college, by *W. J. Beal;* The mechanism of root curvature, by *James B. Pollock;* Remarks concerning the saprophytic fungi grown in the vicinity of Agricultural College, by *B. O. Longyear;* The Russian thistle and tumbling mustard in Michigan, and some Alpena county plants observed in 1896, by *C. F. Wheeler;* Early stages in the development of the pollen in Asclepias Cornuti, by *Fanny E. Langdon;* A remarkable forest in Michigan not hitherto known, by *S. Alexander*. Among the new officers elected are Dr. Volney M. Spalding, president, and Professor C. F. Wheeler, vice president of the section of botany. The secretary of the Academy is Professor Walter B. Barrows, Agricultural College, Michigan.

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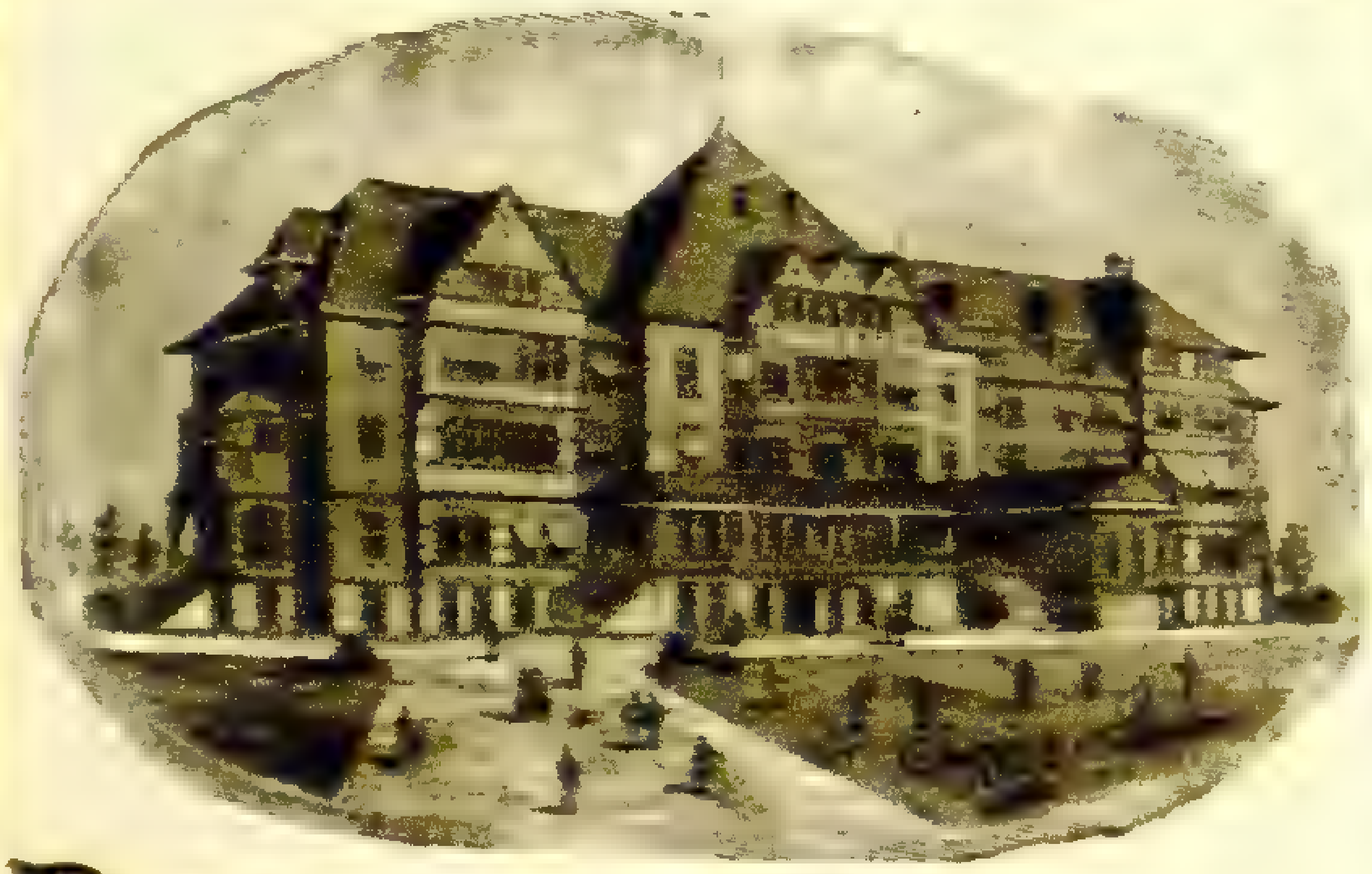

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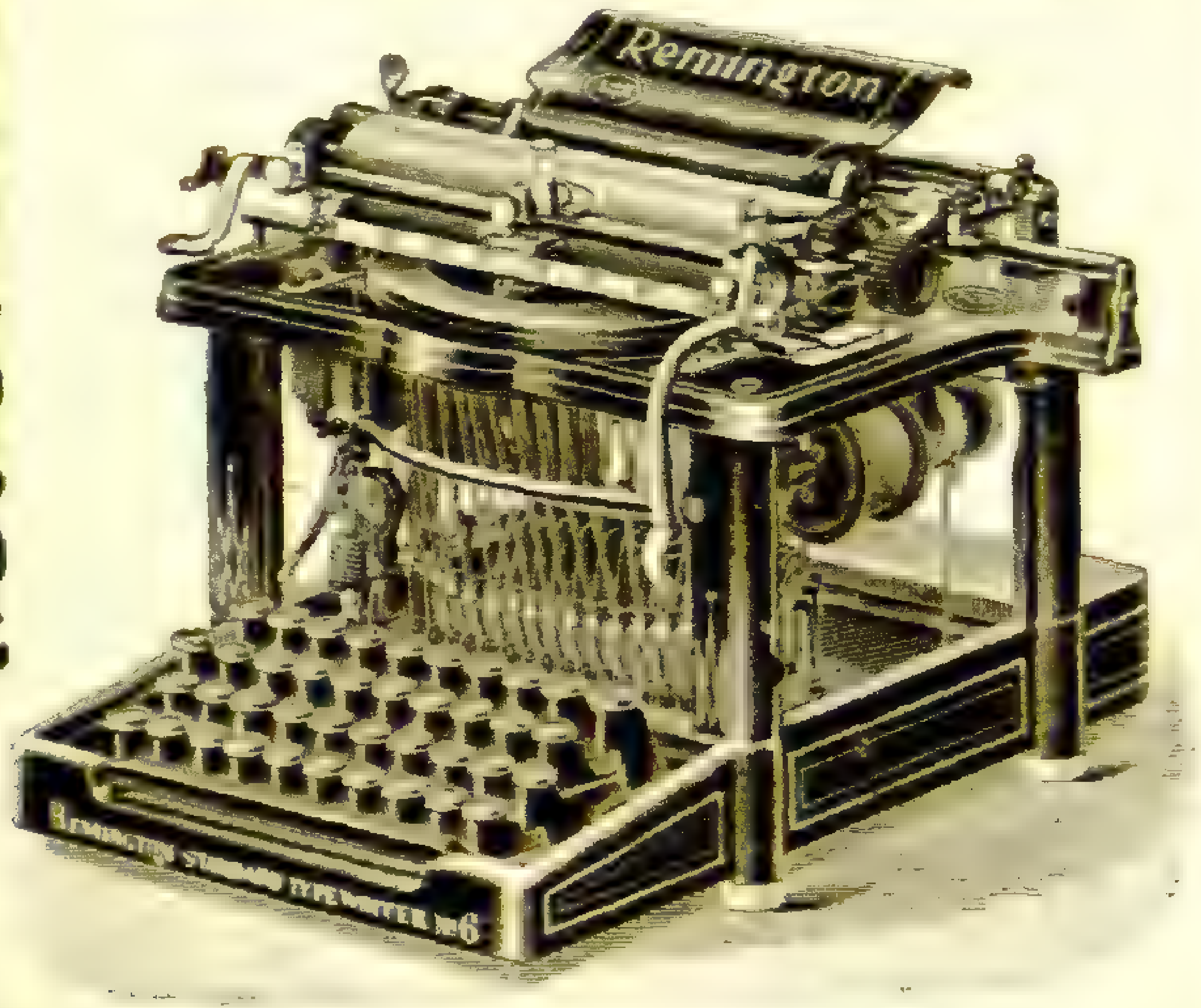
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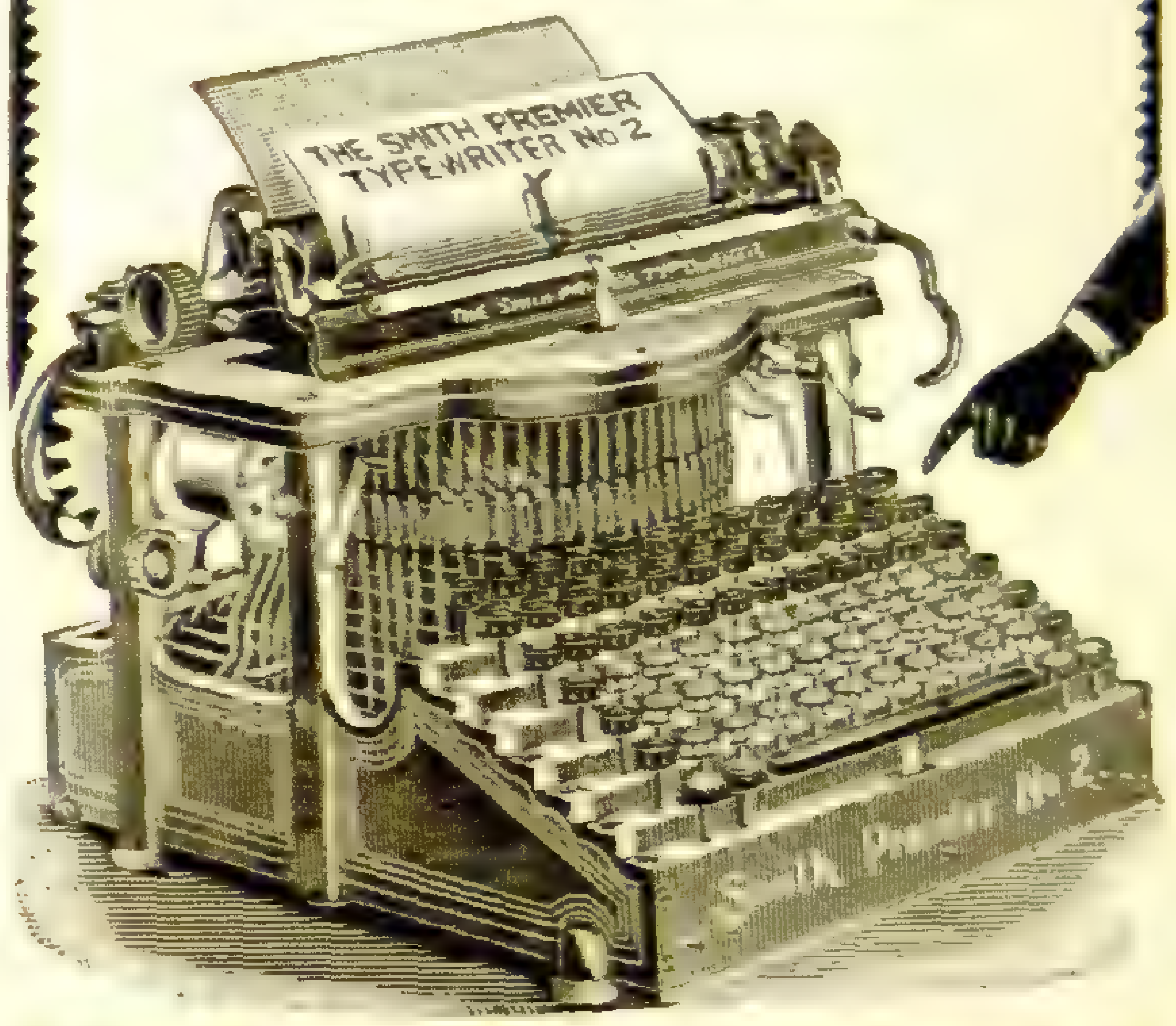
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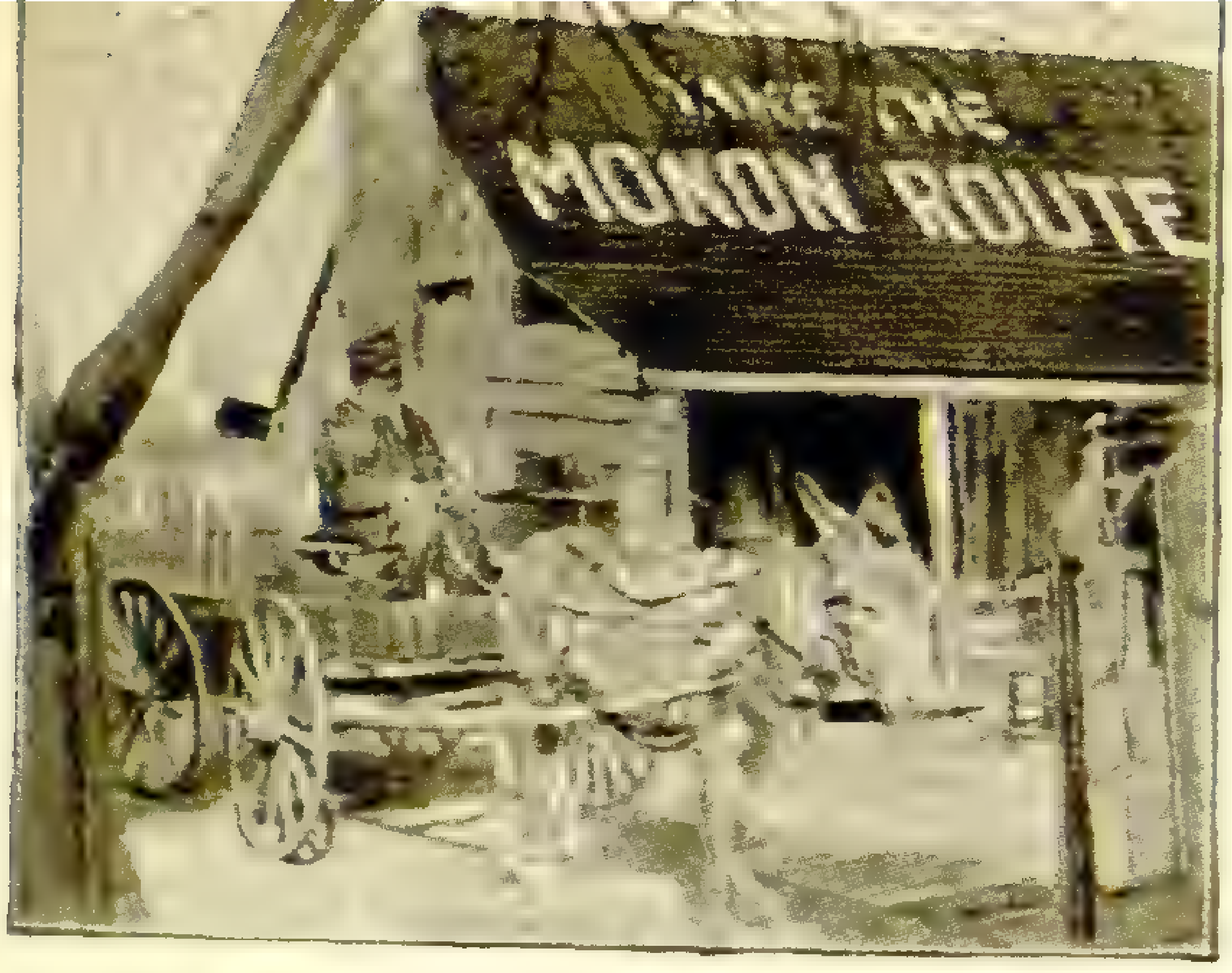

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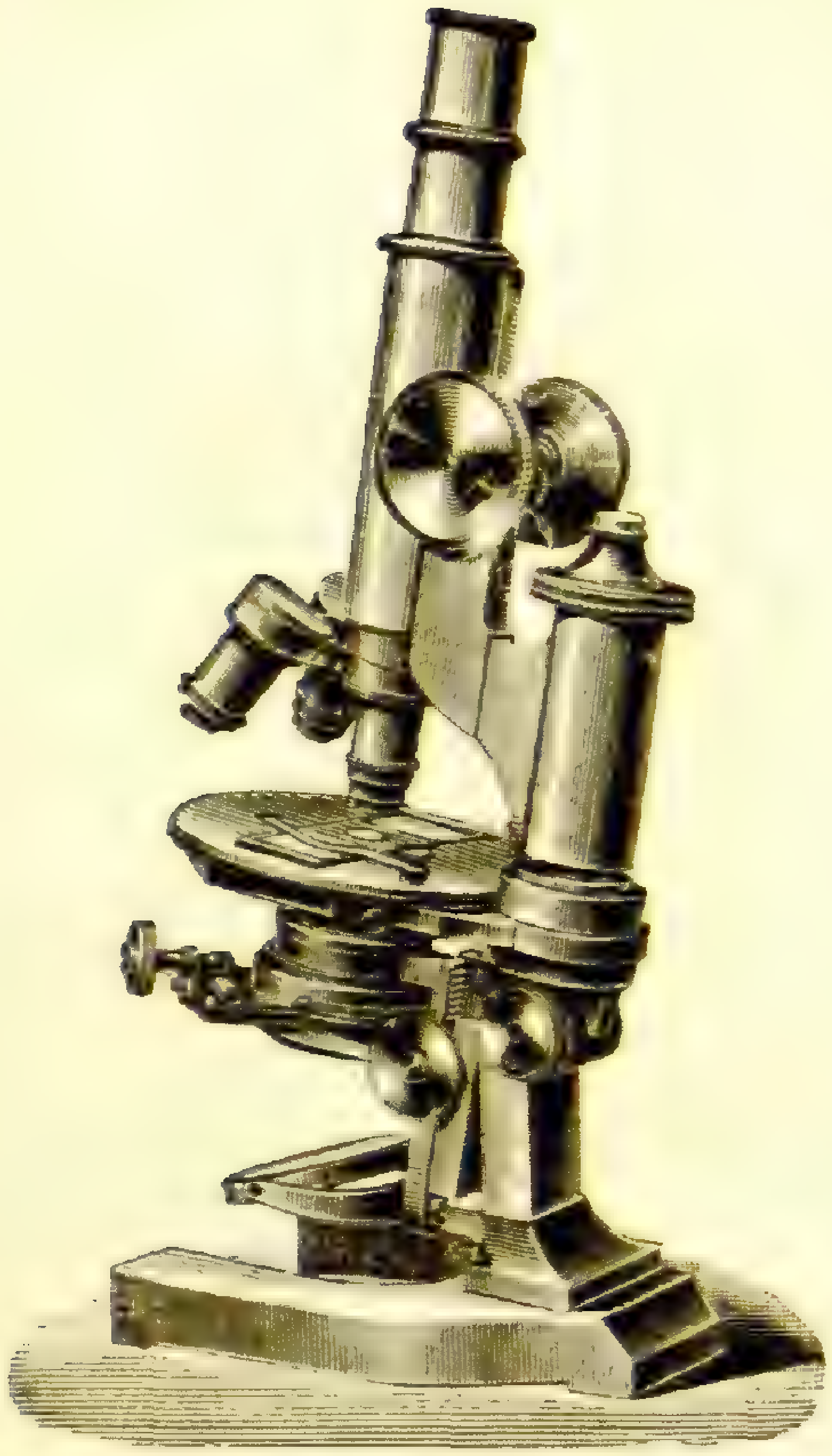

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ROLAND THAXTER.

(WITH PLATES XXX-XXXI)

IN a paper published in the GAZETTE[1] a few years since the writer presented certain notes concerning a curious group of Schizomycetes, which, from the fact that their life cycle is divided into two definitely recurring periods — one of vegetation, the other a period of fructification or pseudo-fructification through the simultaneous and concerted action of numerous individuals — was thought to be sufficiently well characterized to warrant the separation of its members as a distinct order. The name Myxobacteriaceæ was selected as an appropriate designation for them, in view of the very striking similarities which become evident when one compares the life cycle just mentioned with that of the Mycetozoa; the general characteristics of the two periods being, in either case, practically identical, except for the differences presented by the cell structure of the individual organisms concerned. Since the publication of the paper referred to, the remarkable nature of this resemblance has been further enforced through the appearance of a recent paper by Dr. Zukal[2], in which, under the title "Myxobotrys variabilis als Repräsentant einer neuen Myxomyceten Ordnung," he gives an account of a singular plant, at least very like *Chondromyces crocatus* of my former paper, the characters of which are in his opinion so similar to those of the Mycetozoa that he does not hesitate to place the organism in question near Ceratiomyxa among the "Exosporeae." The vegetative mass of Myxobotrys is held to be a true plasmodium which is said to ingest its food like the plasmodium of a myxomycete, and in a similar fashion rids itself of all foreign matters before rising to form its fructification; the gelatinous matrix about the rods being looked upon as hyaloplasm; while the rod-like structures are described as "microsomata" imbedded in it. It is further stated that, as the plasmodium rises to fructify, the microsomata suddenly disappear and are replaced by numerous long cylindrical filaments, and that these same filaments fill the "spores" at maturity, winding about in their interior.

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[1] BOT. GAZ. 14: 389. 1892.

[2] Berichte d. d. bot. Gesell. 14: 340. 1896.

In a more recent "Notiz zu meiner Mittheilung über Myxobotrys variabilis" Dr. Zukal calls attention to the identity of this species with *Chondromyces crocatus*, making further suggestions as to its probable synonymy which will be mentioned below. He further remarks that, strange as it may appear, the present writer's view as to the schizomycetous nature of this organism is worthy serious consideration, although he further asserts his own disbelief in the truth of this assumption, as well as his adherence to the opinion expressed in his first paper, namely, that the organism in question belongs not to the bacteria, but to the Mycetozoa. In view of the striking and important differences which would seem to distinguish Myxobotrys, as described by Dr. Zukal, from any member of the Myxobacteriaceæ with which I am familiar, it is perhaps not altogether safe to assume its identity with *Chondromyces crocatus*, although the two appear to approach so closely in general habit. If, however, we assume this identity and admit for the moment the correctness of Zukal's observations, it must be confessed that his interpretation of the development described by him is quite as remarkable as the facts themselves. A true plasmodium, consisting of a matrix of hyaloplasm wholly destitute of nuclei and apparently of any structure whatever, in which are embedded rod-like microsomata capable of entering upon an independent existence when separated from the plasmodium, as well as possessed of a Beggiatoa-like power of locomotion and a capacity for indefinite multiplication by fission, coupled with a faculty of transforming themselves suddenly into slender filaments, would be sufficiently singular, even were not these same "microsomata" demonstrably cells, similar to the cells of other schizomycetes; and did not these cells, like other bacteria, produce, in a whole series of forms, definitely differentiated spores capable of germination.

That all plasmodia, as suggested by further observations recorded in the "Notiz" just mentioned, are likely to prove similar to the vegetative mass of the Myxobacteriaceæ, and that they will be found to possess a mode of increase, hitherto overlooked, by means of bacteria-like energids, seems unlikely in view of the well known fact that the energids of true plasmodia are potential amœbæ. It is hardly necessary to remark that I am unable to agree with Dr. Zukal in considering the Myxobacteriaceæ members of the Mycetozoa; and further observation of them during the past five years, during which certain species, including *C. crocatus*, have been kept in constant cultivation in my laboratory, has served fully to confirm the correctness of the views previously published in the GAZETTE. Having been occupied during this time with other matters, I have been unable to pay special attention to the group; yet have succeeded in accumulating a certain amount of new material, and have made a few additional observations in connection with the development of its members, the most important of which relate to the sporulation and spore germination of the species of Myxococcus; both which matters were left undetermined in my previous paper. The present note is therefore offered as a further contribution towards a knowledge of the species, as well as of the development of a group of organisms which, as is evidenced by its entire omission from a work like the *Pflanzenfamilien* of Engler and Prantl, does not appear to have received the recognition it well merits. That the family, as predicted in my former paper, is likely to prove by no means numerically insignificant, is indicated by the additions enumerated below, which have for the most part made their appearance by accident, as it were, on laboratory cultures designed for other purposes; and it seems probable that any systematic attempt to enlarge our knowledge of the species could hardly fail to produce interesting results.[3]

It may be remembered that, in arranging the nine species which formed the nucleus of the order, two sub-groups were distinguished; the one including in the single genus Myxococcus all those forms in which the individuals become transformed into definite spores during the period of fructification; while all the remaining forms were included in the two genera Chondromyces and Myxobacter; the individuals in both these instances becoming encysted *en masse*, without being converted into definitely formed spores. In the first category those species in which the spore mass is permanently encysted or definitely coherent at maturity were further distinguished from those in which it soon becomes deliquescent, while in the second category those forms which produce their cysts free in the air (Chondromyces) were separated from those in which the latter are formed embedded in a gelatinous matrix, the two species included in the last mentioned class being placed in the genus Myxobacter, which, as will be presently seen, may be referred with little doubt to Schroeter's Cystobacter.

Although all of the forms described below fall under one or the other of the above categories and no new generic types are included among them, the gross structure of the fructifying condition in several of them presents points of no little interest. In the Myxococcus group, for example, the species previously enumerated were all characterized by a practically sessile habit, and in the absence of a knowledge of their complete life history their close relationship to the more highly developed cystophore-producing forms might well have been questioned. The discovery, however, of the species subsequently described as *Myxococcus stipitatus* serves more definitely to indicate the close relationship between the two groups, since in this instance the spore mass is raised above the substratum on a well developed stalk, corresponding exactly in structure and method of formation to the often highly differentiated cystophores characteristic of nearly all the species of Chondromyces; the only difference being dependent on the fact that in the one case the ultimate mass or masses of individuals become encysted as such, while in the other they form an eventually deliquescent spore mass. A further indication of this relationship is also found in the characters which distinguish *Myxococcus cruentus*, the cysts in this species being very clearly differentiated, with a well defined wall surrounding the mass of spores within, which are themselves embedded in a stringy, coherent though scanty matrix that recalls the corresponding condition found in the cysts of Chondromyces. The spores, moreover, are not as well developed as in the other species of Myxococcus, and seem to suggest a transitional form between a slightly modified rod, such as occurs in the cysts of Chondromyces, and a typical spore like that which is found, for example, in *Myxococcus rubescens*. The general habit of the species closely resembles that of Cystobacter as below emended; and, were it not for the definite spores, might readily be included in that genus. In this connection it may be mentioned, moreover, that an examination of the contents of mature cysts of *Cystobacter fuscus* shows that the rods in this case are more definitely modified than in the species of Chondromyces; their walls being visibly thicker and their contents enclosing the same definitely formed nucleus-like body described below as characteristic of the developing spores of Myxococcus. It should be mentioned, however, that I have not yet had an opportunity of reexamining fresh material of the other species of Myxobacter, in order to ascertain whether they exhibit similar modifications.

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[3] Since the present paper was in press Messrs. Pound and Clements in their "Rearrangement" of the North American Hyphomycetes (*Minnesota Botanical Studies*, 44) have referred the lichenicolous species of Illosporium to the Myxobacteriaceæ. The species of this genus, however, are semi-sclerotic conditions of hyphomycetous fungi, which, in some instances at least, are connected with species of Nectria, and in no case can be mistaken for Myxobacteriae. Why these authors retain the genus Stigmatella in their rearrangement is not apparent.

The most important fact, which further examination of the sporiferous forms has served to determine, is connected with the process of spore formation and germination, matters which in my former paper were left in doubt from lack of exact observations; certain appearances which one often sees in the rising masses of spores, having, in the first instance, led to the erroneous suggestion there made that they were produced in chains, while the process of their germination was also left undetermined. Further and more extended examination of these processes in pure cultures of *Myxococcus rubescens* shows that my previous conclusions in regard to these matters are not in accordance with the facts, since the phenomena in either case prove to be such as would naturally be associated with the development of organisms of this nature.

As was mentioned in my previous account, sporulation appears invariably to take place gregariously, if one may use such an expression to indicate that isolated rods have never been seen to become thus transformed. The impulse to sporulate thus seems to be, as it were, contagious, and takes possession of a large number of rods simultaneously, which, in their turn, exercise a similar influence on other rods in their more immediate vicinity; so that a condition of things exists at this period which serves still further to accentuate the remarkable correspondence between the Myxobacteriaceæ and the Sorophoreae or pseudoplasmodium-forming Mycetozoa. From the fact, therefore, that sporulation only occurs in the rising rod mass, and that it takes place more or less continuously, in a narrow zone only, below the spore mass, which for a certain period is thus constantly being augmented from below, direct observation of the process, as for example in Van Tieghem cells, is almost impossible. It is therefore only by removing from pure cultures and crushing whole guttulae that the successive stages can be obtained. Both rods and spores are in general so minute and become so promiscuously intermingled by this treatment that, except in very favorable instances, the true nature of the process is not at once apparent, although, when once ascertained, it has been readily demonstrated in all the species examined. By removing and crushing guttulae of *Myxococcus rubescens*, for example, which have formed on agar in pure cultures, selecting preferably such as have recently begun to rise from the substratum, it is not difficult to obtain in abundance all stages illustrating the process of sporulation; and by staining the material with Delafield's haematoxylin, or with eosin, the mature spores which resist stains are at once differentiated in the preparation from the immature conditions. It may be thus definitely determined that sporulation consists in the direct transformation of single rods into single spores. By a gradual inflation, involving a corresponding shortening of the rod in the direction of its long axis, even the longest individuals eventually assume a spherical form, and through the deposition of material on the inner surface of their walls are gradually converted into thick-walled refractive spores. The successive steps in this transformation may be more readily understood by reference to *fig. 36* (*a–j*), and it may be mentioned that, as is indicated in the figures, a marked enlargement is first apparent at one end of the rod, the progressive transformation gradually involving the whole cell. As in other members of the group, the rods, when they run together to sporulate or to produce cysts, become thickened and somewhat shortened, and the more densely granular portion of their contents tends to collect in somewhat definite masses. Even before the rods have begun to show the terminal inflation just mentioned, one of these masses towards the extremity of the cell may be seen to be distinctly larger than the rest, which tend to disappear as the transformation of the rod progresses; the larger mass becoming more and more distinct and clearly defined, taking a deep stain with either eosin or haematoxylin. As the spore assumes a more rounded form this deeply staining mass comes to occupy a central position, and has the appearance of a well defined nucleus-like body (*h* and *i*), which continues to stain readily and deeply until the wall becomes so thick that the whole spore remains bright and refractive and impenetrable by stains, except after they have acted for a considerable time.

The occurrence of this nucleus-like body in the spores of Myxococcus led me to examine more carefully the conditions found in the rods of Chondromyces while becoming encysted, and in these instances also the granular more deeply staining portions of the cell contents were found to collect in more or less definitely circumscribed masses. In Chondromyces this mass, though more frequently single, was found to be generally elongate, occupying a central or usually somewhat lateral position (*fig. 15*). In the rods which compose the ascending "pseudoplasmodium" in this genus, the granular masses are very readily demonstrated by staining, and have in general the appearance represented in *fig. 14*, a small mass being commonly distinguishable at either end of the cell, while a much larger and more irregular one is apt to occupy a central position. In *Cystobacter fuscus*, on the other hand, a portion of the more deeply staining contents, as has been previously mentioned, was found to become definitely aggregated into a well defined nucleus-like body corresponding exactly in its general appearance to that of the sporulating forms just described, an accompanying thickening of the wall being in many cases distinctly visible.

Such transitions between a slight and a complete transformation in the rods at the period of fructification are doubtless correlated with an inverse differentiation of the cyst, the most perfectly formed spores being those characteristic of deliquescent guttulae, while the least well marked differentation of the individual rods occurs in forms like *Chondromyces crocatus* in which the cysts reach a maximum development.

At the time when my first notes were published no satisfactory data had been obtained in regard to the germination of the spores in any case. In cultures of Myxococcus made from material which had been kept air dry for several months, the spores when placed in a nutrient medium gradually assumed a short stout rod form; but no separation of this body from the spore wall was noticed nor was any further development of the rods by fission seen, although both may have been overlooked. Recently, however, by cultivating in Van Tieghem cells the spores of *M. rubescens* taken from pure agar cultures, I have repeatedly obtained abundant germinations and have been able to follow the whole process with a $\frac{1}{16}$ oil immersion. The most convenient mode of procedure for this purpose I have found to be as follows. A small amount of the spore-material, which is easily obtained free from rods when taken from pure agar cultures, was spread near the center of a sterilized cover glass; and when thoroughly dried on, so that the spores adhered firmly, was covered with a thin slice of nutrient agar transferred directly from the surface of a sterilized agar tube. The coverglass was then mounted on the cell in the ordinary fashion, a small amount of water containing unicellular algæ being added within it to furnish moisture and oxygen. The spores were thus firmly fixed in definite positions on the under side of the cover and could be readily examined directly with the immersion objective. In these cultures the germinations began to be visible in from one to two weeks, seven days being the shortest period within which they occurred; and in all cases they were of a single type, no instances being noticed in which the spores underwent the gradual change of form above described, which on the assumption that no separation of the rod from the spore wall occurred, must, I think, be considered an abnormal phenomenon.

The first indication of germination, as shown by preparations which, since they could not otherwise be stained, were made directly from the Van Tieghem-cell cultures, consists in the slight enlargement of the spore and the recovery of its power quickly to absorb stains. Such deeply stained spores are conspicuous in a field, contrasting with the still refractive and wholly colorless ones in which germination has not yet commenced. The walls of the spores thus stained (*fig. 34*) appear as if irregularly corroded by absorption from within, and eventually become comparatively thin, often more so at one or two definite points than elsewhere. At such a thin point a protrusion is then seen, which gradually increases, and at the same time the outline of a stout rod, sometimes bent or irregularly swollen, becomes more and more distinct within the spore-wall (*fig. 35*). The emerging rod elongates with considerable rapidity, until it becomes about twice as long as the diameter of the spore. In several cases it was then seen to slip out free from the spore wall (*fig. 35, h*, and, four minutes later, *i*) which remains for a time as an empty shell, but gradually dissolves and disappears. More commonly, however, the emerging rod does not escape from the spore wall, but remains attached to the latter, being apparently fixed within it, elongating and dividing as is indicated in the series of figures (*c–g*) which represent the successive stages in the development of such a rod. In very many cases the emerging rod may be seen, as in *j* and *k*, to have penetrated the spore wall on both sides, so that two free ends project and continue to grow and divide as usual till the old spore wall disappears through absorption. That such appearances do not represent accidental superpositions, I have been able to determine to my own satisfaction.

The addition of the following species, the number of which might be augmented by others that from lack of proper material I have been unwilling to publish, more than doubles the number of representatives of the group formerly enumerated and serves to enforce with even greater emphasis than was before possible the fact that the course of development of these organisms forms a distinct departure from that of other Schizomycetes, in that their life cycle, as has been pointed out, is divided into two distinct periods; the one of vegetation, the other of fructification or pseudo-fructification resulting from the concerted action of many independent individuals toward this very definite end. This view is here reiterated for the reason that in one of the few references to the group that have come to my notice since the publication of my first paper, it is held that the aerial character of the cysts, and not the circumstance just mentioned, should be regarded as the crucial point of difference between the Myxobacteriaceæ and other Schizomycetes. As a matter of fact, the cysts or spore masses are not always produced vertically free from the substratum; and were forms discovered, as they well may be, which reached maturity in water or embedded in the nutrient matrix, they would still be clearly distinguished as above indicated.

Among the forms described below belonging to the genus Chondromyces the most striking is that which I have called *C. apiculatus*, an African species distinguished from its ally, *C. crocatus*, by a curiously well defined and constant specific character, which, though quite as reliable as a well marked difference in spore-form would be in the higher fungi, is here dependent on a slight variation in the movements of the individuals composing the ultimate rod masses during the maturation of the cysts, the invariable recurrence of which gives to the mature cysts a specific form. This form results from the fact that the cyst, when it has received all the rods destined for it, becomes at first fusiform, as in *C. crocatus*, the extremities, however, being more attenuated than in this species; but while in *C. crocatus* the mass of rods composing it, together with the film of hardened gelatinous material which has been secreted around them, gradually assumes the subconical shape characteristic of the species, the individuals in the cyst of *C. apiculatus* migrate from each extremity towards the center, this movement taking place within, and without involving the surrounding membrane which is thus left empty at each end, the empty portions corresponding to the shrivelled appendages which distinguish the mature cysts.

Among the other species the most interesting are perhaps the *Cystobacter erectus* and *C. fuscus* of Schroeter. Of these the former (*figs. 16–19*), although undoubtedly a Chondromyces, proves quite distinct from *C. aurantiacus* with which I was formerly inclined to unite it; while the latter, since it is doubtless congeneric with the species of my own genus Myxobacter, may be considered as the type of the genus Cystobacter, a name which, of course, antedates my own.

Chondromyces apiculatus, nov. sp. *Plate XXX. figs. 1–15.*—Cystophore stiff, rigid, simple, rarely sparingly branched, bearing the single spherical cyst-mass terminally. Cysts very variable in form, shape and size, cylindrical to broadly turnip-shaped, the young cysts fusiform or nearly so, the rods retreating from each end towards the center and leaving behind a shriveled membrane forming a basal and terminal appendage, the latter longer and pointed. Color bright orange. Rods 1 by 3–20μ, sometimes longer. Head of cysts 136μ, average about 200μ. Cysts, turnip-shaped form, average about 35μ broad by 28μ long; cylindrical form, average 35 by 18μ. Cystophores about 500–1000μ in height. All dimensions subject to great variations.

On dung of antelope from Liberia, Africa.

Two or three cystophores of this striking species made their appearance on some antelope dung sent me from Africa, which I owe to the kindness of Mr. F. C. Straub. Having been successful in propagating it from these original specimens I have kept it in constant cultivation for more than a year, and have thus been able to determine the constancy of the characters which separate it from its nearest ally, *C. crocatus*. Its general color is somewhat more orange and less yellow than that of the last mentioned species, and though rarely branched it never develops the highly differentiated cystophores so characteristic of this species when growing under favorable conditions. The head is almost invariably solitary under the most favorable conditions, and the mature cysts are always characterized by the peculiar shrivelled appendages to which reference has already been made above. The variations in the form of the cysts is very great, the most typical and striking having the turnip or onion-shape represented in *figs. 5, 10, 11*. The cysts not infrequently fuse laterally while in process of formation so that conditions similar to those represented in *figs. 8, 12* are sometimes found, which have resulted from the fusion of two and three cysts, respectively. The germination of the cysts is as readily observed as in *C. crocatus*, but, unlike that species, takes place not only normally at the base, but also at the apex, as is represented in *fig. 13*. The species never grows as readily or as luxuriantly as *C. crocatus*, and I have found great difficulty in inducing it to grow pure on nutrient agar, on which it develops very slowly, and seldom produces cysts and cystophores.

Chondromyces gracilipes, nov. sp. *Plate XXXI, figs. 20–24.* —Color orange red. Cystophore simple, tapering distally to a pointed apex, rigid and persistent on the substratum. Cysts solitary, terminal, oblong to oval, rounded distally, somewhat flattened basally, caducous. Rods minute, slender, 0.6 by 2–5μ. Cystophore 25–40μ high. Cysts average about 25 by 35μ.

On rabbit dung, Arlington, Mass.

This minute and well marked species made its appearance on a laboratory culture of rabbit dung which it covers with a powdery orange coating. It appears to be constant in its characters, and is abundantly distinct from any of the other known species of the genus.

Chondromyces erectus (Schroeter). *Plate XXXI, figs. 16–19.*

Cystobacter erectus Schroeter, Kryptogamenfl. v. Schlesien, III Band, 1 Lief. p. 170.

Color orange red turning to chestnut brown. Cystophores fascicled, united at the base in groups, above simple or sparingly branched, bearing a single terminal broadly oblong or rounded cyst on a broad base. Cystophores withering at maturity so that the cysts often appear sessile. Rods 0.9 by 2–5μ or longer. Cysts average about 50 by 40μ. Cystophore 60–300μ or more in height.

On horse dung in laboratory cultures. Cambridge, Mass.

This species has appeared repeatedly in laboratory cultures within the past few years and seems abundantly distinct from its nearest ally *C. aurantiacus*, its fascicled habit, single terminal cysts, and the chestnut brown color of the latter when mature serving to distinguish it readily from any of the varieties of *C. aurantiacus* with which I am familiar. The cysts of the latter sometimes become brown with age, but in the present instance they assume this color as soon as they are mature.

CHONDROMYCES AURANTIACUS (Berk. & Curtis) Thaxter.

In my former paper on the Myxobacteriaceæ it was suggested that this species was probably synonymous with *Stilbum rhytidospora* figured by Berkeley and Broome in their Fungi of Ceylon, as well as with the *Polycephalum aurantiacum* of Kalchbrenner and Cooke described from African specimens. Although this suggestion was based only on an examination of the figure of the former and description of the latter, it proves to have been correct according to the statement of Massee,[4] who has examined the types of these two forms, as well as that of *Stigmatella aurantiaca*. The synonymy formerly given with a query may therefore be considered correct. The species has been found commonly in many localities and has been sent me from Ohio by Professor Morgan. It has also made its appearance in abundance and in the typical form on the same antelope dung from Africa which yielded *C. apiculatus*, and under conditions that made its African origin unquestionable. The species is totally distinct from *C. crocatus*, with which Dr. Zukal would unite it, both in the form and character of its cysts and cystophores, as well as in its color, and is in general very constant, although what appears to be a variety of the same form accompanied the Liberian material and differs from the fact that it is larger and often copiously branched, one "individual" thus producing a number of heads.

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[4] Grevillea **21**: 124.

CYSTOBACTER FUSCUS Schroeter. *Plate XXXI, figs. 37–39.*
Schroeter Kryptogamenfl. v. Schlesien, III Band. 1 Lief. p. 170.

Color orange red becoming chestnut brown, the rising rod masses pale flesh colored. Cysts formed by the separation of the parts of a more or less convoluted rod mass, nearly spherical to long-oblong or irregularly elongated at maturity, surrounded by a gelatinous matrix, heaped together or lying in one plane on the substratum, each cyst surrounded by a thin, papery, separable chestnut-brown wall; when dry dark dull red. Rods slender, elongate, 0.6 by 5–12 μ. Cysts 50–150 by 50–70 μ.

On dung of rabbits from southern California.

This interesting form made its appearance in abundance, together with *Myxococcus coralloides*, *Pilaira Cesatii*, and several other interesting plants, on rabbit dung from southern California, for which I am indebted to Mr. F. H. Billings. It is a conspicuous species, growing and producing its cysts readily on agar, and seems to correspond in all essentials to the generic type which I formerly called Myxobacter from the fact that its cysts are embedded at maturity in a mucus envelope. Its characters seem to be so nearly identical with those of Schroeter's species that I have no hesitation in referring it to *C. fuscus*, which, it may be remarked, was also found on the same substratum. Assuming that this reference is correct, Myxobacter must be superseded by the earlier name, under which should be included *Cystobacter aureus* and *C. simplex*.

Myxococcus stipitatus, nov. sp. *Plate XXXI, figs. 30–33.*

Color white to pink or flesh color. Spore mass becoming deliquescent, subspherical, formed at the apex of a well developed stout stalk which raises it free above the substratum. Rods 0.5–07 by 2–7 μ or longer. Spores oval, 0.8–1.2 by 1–1.15 μ. Spore mass about 175 μ in diameter. Stalk 100–200 by 30–50 μ.

Dung of sheep, pig, and other animals. Cambridge, Mass.; Kittery Point, Maine; Burbank, Tennessee.

This striking form has made its appearance not infrequently on laboratory cultures and grows luxuriantly on nutrient agar, although it does not fructify on this substratum as readily as the sessile species. The form obtained on pig dung at Burbank, Tenn., was distinctly smaller in habit and milky white in color; but cultures of this variety on agar reverted to the ordinary pinkish form from which it can hardly be distinct. As already mentioned, the stalk is formed in the same way that the cystophores of Chondromyces are produced, and is persistent after the spores have separated from it.

Myxococcus cirrhosus, nov. sp. *Plate XXXI, figs. 25–27.*

Color pale reddish or flesh colored. Spore mass more or less elongate, erect, the base slightly swollen, the distal portion tapering to a rounded apex. Spore irregularly spherical, about 1 μ in diameter. Rods 0.8 by 2–5 μ or longer. Spore mass 50–100 μ high, about 20 μ in diameter at the base.

On grouse dung from Readville, Mass.

This form appeared on a laboratory culture and is so minute and inconspicuous from its pale color that it is seen with difficulty, the more so since the bases of the spore masses are usually more or less embedded in the substratum. The spores although somewhat loosely coherent at maturity do not form a deliquescent mass, so that the species is evidently allied to the section of the genus which includes *M. coralloides.*

Myxococcus cruentus, nov. sp. *Plate XXXI, figs. 28–29.*

Color deep blood red. Cysts regularly spherical, surrounded by a more or less well defined rind or wall within which the spores are embedded in a scanty and amorphous matrix. Rods 0.8 by 3–8 μ. Spores oval or irregularly oblong, 0.9–1 by 1.2–1.4 μ. Cysts 90–125 μ in diameter.

On cow dung, Burbank, Tennessee.

This species was found in woods covering the substratum with a blood red coating resembling some dark red Nectria. The cysts are densely aggregated, remarkably uniform in shape and size, and are peculiar from the presence of a moderately well defined wall to which attention has been called above. The spores are more than usually irregular in size and form, and are less well defined than in the other species, resembling in some respects the thickened individuals which occur in the cysts of Chondromyces. The species was not cultivated, and no satisfactory material of its vegetative condition was obtained.

Cambridge, Mass.

EXPLANATION OF PLATES XXX AND XXXI.

The figures are from ink drawings reduced about one-fourth by photolithography. The letters and numbers refer to the Zeiss or Leitz objectives and eyepieces used in making the original drawings. The approximate magnifications in diameters of these combinations, allowing for projection, are (in the original) as follows: A, oc. 4, 180 : C, oc. 2, 230 : C, oc. 4, 400 : D oc. 2, 380 : D, oc. 4, 700 : $\frac{1}{16}$ (oil), oc. 4, 1900 : $\frac{1}{16}$ (oil), oc. 12, 3300.

Chondromyces apiculatus Thaxter.

FIG. 1. Rising rod mass. A 4.

FIG. 2. Branching cystophore, the cysts just beginning to bud out from right head. A 4.

FIGS. 3–4. Typical cystophores with cysts in different stages of development. A 4.

FIG. 5. Cystophore bearing mature cysts of the turnip-shaped type. A 4.

FIG. 6. Young cyst before the rods have retreated from either end. D 4.

FIGS. 7–12. Mature or nearly mature cysts, *figs. 10, 11* of the turnip form, the rest of the subcylindrical type; *fig. 8* showing the union of two and *fig. 12* of three cysts by lateral fusion. All D 4.

FIG. 13. Cyst "germinating" at both ends in the normal fashion. D 4.

FIG. 14. Rods from rising rod mass, stained with Delafield's hæmatoxylin. $\frac{1}{16}$, 12.

FIG. 15. Encysted rods from mature cyst, stained with hæmatoxylin. $\frac{1}{16}$, 12.

Chondromyces erectus Thaxter.

FIG. 16. Cystophores bearing mature cysts showing habit. C 2.

FIG. 17. Young cystophores on which the cysts are just beginning to form. C 2.

FIG. 18. Mature cyst isolated. D 4.

FIG. 19. Group of rods. $\frac{1}{16}$, 4.

Chondromyces gracilipes Thaxter.

FIG. 20. Mature cystophores and cysts. C 2.

FIGS. 22–23. Mature cystophore and cyst. D 4.

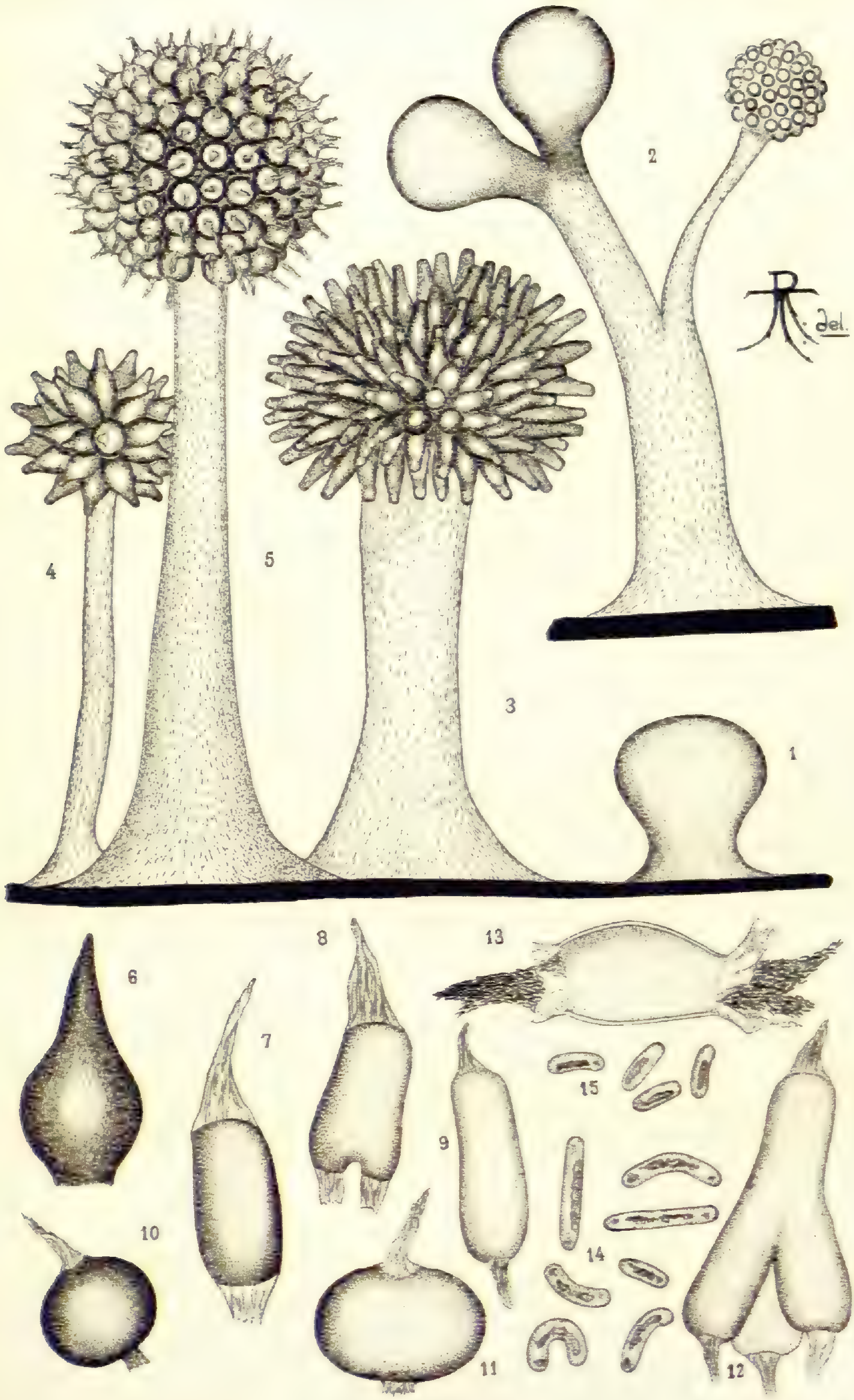
FIG. 24. Group of vegetative rods. $\frac{1}{16}$, 4.

Myxococcus cirrhosus Thaxter.

FIG. 25. Three mature spore masses. C 4.

FIG. 26. Group of rods. $\frac{1}{16}$, 4.

FIG. 27. Group of spores. $\frac{1}{16}$, 4.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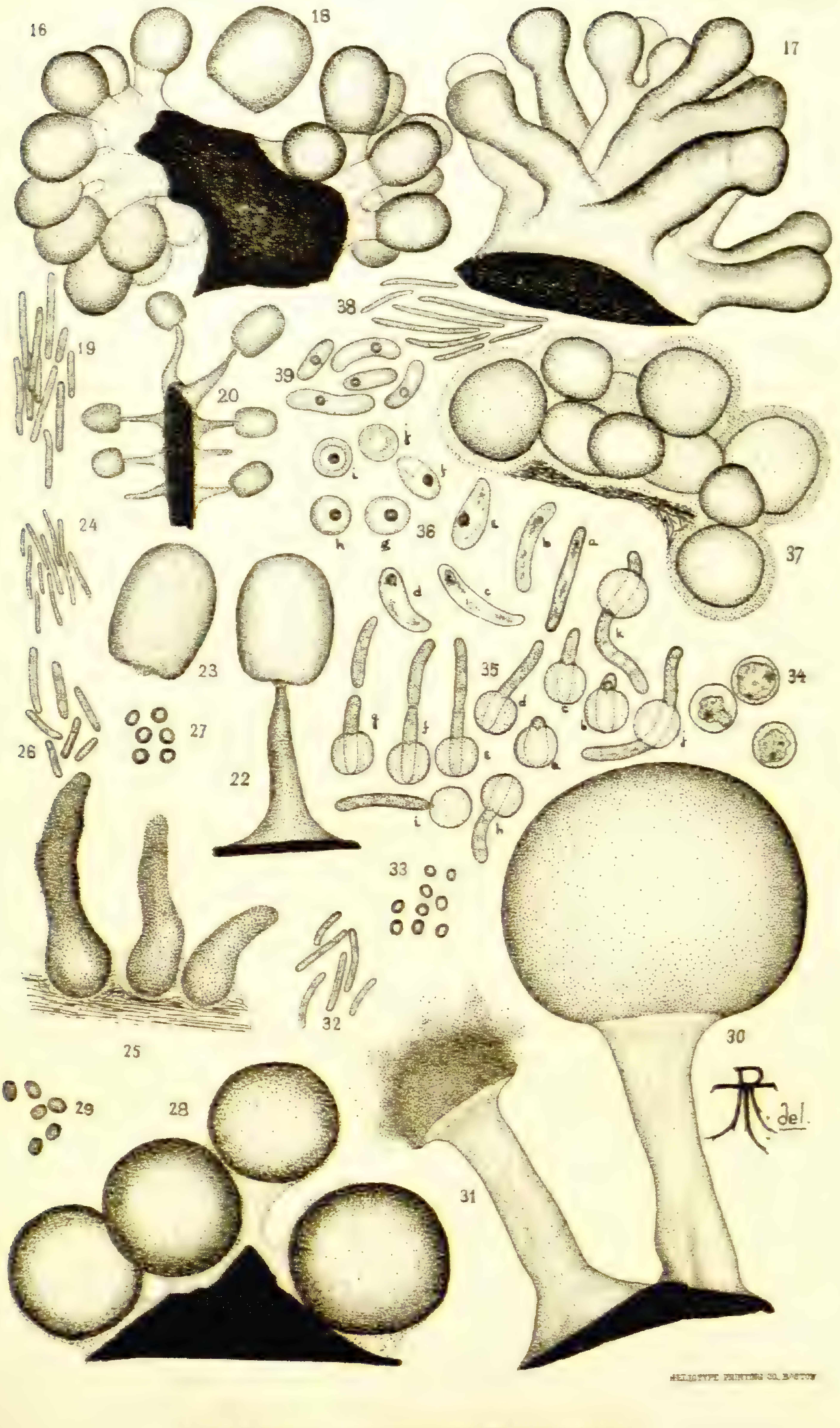
THAXTER on MYXOBACTERIACEÆ.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HELIOTYPE PRINTING CO. BOSTON

THAXTER on MYXOBACTERIACEÆ.

Myxococcus cruentus Thaxter.

Fig. 28. Group of cysts, that at the left showing thickness of cyst wall. C 2.

Fig. 29. Group of spores. $\frac{1}{16}$, 4.

Myxococcus stipitatus Thaxter.

Fig. 30. Stalk with spore mass still intact. C 2.

Fig. 31. Stalk from which the deliquescent spore mass has been removed. C 2.

Fig. 32. Rods. $\frac{1}{16}$, 4.

Fig. 33. Spores. $\frac{1}{16}$, 4.

Myxococcus rubescens Thaxter.

Fig. 34. Three spores preparing to germinate, stained with eosin, from Van Tieghem cell-culture. $\frac{1}{16}$, 12.

Fig. 35. Different stages in the spore germination; *c–g*, division of rod while still adherent within spore wall; *h–i*, rod escaping from spore wall; *j–k*, rod emerging from spore wall on both sides. Drawn from living material in Van Tieghem-cell. $\frac{1}{16}$, 12.

Fig. 36. Successive stages in spore formation; from preparation stained with Delafield's hæmatoxylin, showing deeply staining nuclear-like body and gradual transformation of rod to spherical spore. $\frac{1}{16}$, 12.

Cystobacter fuscus Schroeter.

Fig. 37. Groups of mature cysts removed from substratum. D 2.

Fig. 38. Vegetative rods. $\frac{1}{16}$, 4.

Fig. 39. Rods separated from mature cysts by crushing, and stained with eosin, a nucleus-like body distinct in each.

CONTRIBUTION TO THE LIFE HISTORY OF LILIUM PHILADELPHICUM.[1]

INTRODUCTION.

JOHN M. COULTER.

A group of research students, in connection with a general study of monocotyledons, selected *Lilium Philadelphicum* as a suitable type for somewhat special study. The end in view was to examine those structures so fully described by Guignard for *L. Martagon*, and treated in a supplementary way by subsequent investigators of the same plant. Abundant material of the local *L. Philadelphicum* was obtained, and the cultivated *L. tigrinum* was used also for comparison. The numerous preparations of thirteen investigators gave unusual opportunity for a broad range of observation, so that the facts herein set forth may be regarded as fairly established. As to questions of interpretation, there may well be diversity of opinion, as the present necessities of the case make almost every step in interpretation an inference. It is evident that the association of phenomena will suggest a causal relation, whose reality is plainly only an inference. Moreover, the comparatively obscure structures concerned in cell activity are peculiarly open to misinterpretation, both as to origin and function. The subject, therefore, is one in which dogmatism is singularly inappropriate, and in which every proposed causal sequence of events must be regarded as a suggestion rather than as an established fact.

Inasmuch as this work upon Lilium was but supplementary to the more formal investigation in which each investigator is engaged, my original purpose was to organize under a single caption all of the results that seemed worthy. As the work developed, however, certain parts of it seemed to demand more special attention. These special investigations were undertaken by Mr. Chamberlain and Mr. Schaffner, who have made an independent presentation of their results, for which they are entirely responsible. This contribution, therefore, is made up of three distinct and independent papers, each with its own plates, but naturally brought together by the nature of the subject.

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[1] Contributions from the Hull Botanical Laboratory. V.

My own part is the organization of observations made by the group of students referred to, in so far as they pertain to the embryo sac, fertilization, and the embryo. Mr. Chamberlain, from his own observations, deals with the pollen grain; while Mr. Schaffner presents his own observations and conclusions in reference to certain cytological phenomena connected with the "reduction division" in the embryo sac.

The material used was fixed in Flemming's weaker solution, Merkel's fluid, 1 per cent. chromic acid, 1 per cent. chromic acid with a trace of acetic acid, and picric acid.

Xylol was used almost exclusively to precede the paraffine bath. Serial sections were cut with a Thoma microtome, usually 5 or 10 μ thick, and occasionally but 1 μ thick.

A large number of stains and combinations was used. Cyanin and erythrosin proved excellent for most stages in the development of the macrospore; Delafield's haematoxylin is to be recommended for embryos; safranin with gentian violet and orange G gave good results in staining pollen grains; Heidenhain's iron alum haematoxylin used alone or with erythrosin or orange G gave by far the best preparations for cytological study.

I

THE EMBRYO SAC AND ASSOCIATED STRUCTURES.

JOHN M. COULTER.

(WITH PLATES XXXII–XXXIV)

The results here recorded traverse ground which has become very familiar. It will not be necessary, therefore, to make extended mention of all the phenomena, but to discuss only certain points which seem to merit comment. It seems best, however, to preserve the sequence of events for the benefit of those who may not have access to the more extensive papers. The students whose observations have supplied the data for this portion of the contribution, and whose individual contributions may be recognized by the initials appended to the different figures, are Otis W. Caldwell, John G. Coulter, Henry C. Cowles, T. C. Frye, Nina D. Holton, Florence M. Lyons, William D. Merrell, Mabel C. Merriman, and Wilson R. Smith.

DEVELOPMENT OF THE EMBRYO SAC.

A single large hypodermal archesporial cell very early makes its appearance, distinguished by its size, contents, and very prominent nucleus (*fig. 1*). No evidence of the cutting off of a tapetal cell, or a division into potential macrospores was detected. The sequence of cell divisions usual in angiosperms is entirely suppressed, and the archesporial cell develops directly into the macrospore (embryo sac). It will be remembered that there are three possibilities in what may arise from the archesporial cell of angiosperms. It may, and apparently usually does, give rise at its first division to a primary tapetal cell and a primary sporogenous cell, each of which may give rise to a more or less extensive cell progeny; or it may, less frequently, give rise to no tapetal region, but play the part of a primary sporogenous cell and divide into potential macrospores; or it may, apparently exceptionally, develop directly into the fertile macrospore. This extreme shortening of the history of the embryo sac, recorded as yet only for Lilium and certain allied liliaceous genera, obliterates the distinctions between archesporial cell, primary sporogenous cell or mother cell, and macrospore, so far as distinct cell existence is concerned, but what the ellipsis involves in nuclear and cytoplasmic changes is worthy of research. Certain it is, that this remarkable cell has a relatively long existence in the uninucleate condition, brought to a close by its rapid enlargement. As there is no tapetum, and no periclinal divisions occur in the epidermis to increase the mass of the nucellus toward the micropyle, the encroachment of the enlarging macrospore is at first chiefly upon the tissues beneath.

This enlargement is the first step in the "germination of the macrospore," and when the sac has become considerably elongated the first nuclear division occurs near the center, the axis of the spindle being longitudinal (*fig. 2*), and the daughter nuclei passing to their polar positions. A more detailed view of the antipodal end of this first spindle, at an earlier stage, while the chromosomes are still distinct, is given in *fig. 3*, showing the usual transient cytoplasmic radiations about the chromosome group, and the definite relation of the larger ones to the micronucleoli. The cytological phenomena connected with this division, known as the "reduction division," form the subject of Mr. Schaffner's paper. With such an abbreviated history as that of the macrospore of Lilium the division representing the reduction division is evident, but in most angiosperms the place of this special division in the history of the macrospore is not so clear.

Immediately after the placing of the two nuclei the second divisions occur (*figs. 4–8*), the micropylar spindle being transverse, the antipodal one longitudinal. In *figs. 4* and *5* the reduction number of chromosomes is apparent in the micropylar spindle, while a largely increased chromatin mass is apparent in the antipodal spindle. Very soon the resulting nuclei shift their positions more or less (*figs. 7, 7a, 8*), so that the directions of the two spindles are lost. The persistence of the spindle fibers (*figs. 7, 7a*) is a common phenomenon in the embryo sac divisions, and often helps to indicate the shifting of the freed nuclei.

In this second division certain phenomena were noted by Miss Merriman which deserve mention. The occasional occurrence of multipolar spindles in Lilium is well known, and *figs. 9–12* may be taken to represent them. As these spindles are associated with exceptional conditions of the chromatin band, and occurred in a single ovary, they suggest a very unusual and possibly a pathological condition. With the claims made for the relation between the multipolar spindle and the bipolar spindle, it is interesting to note that among the hundreds of embryo sac spindles of Lilium that passed under our observation, multipolar spindles were found in but a single ovary. In *fig. 9*, representing an antipodal spindle, the chromatin band seems to be arranged in continuous loops the full length of the spindle. In *fig. 10*, representing the micropylar spindle of the same sac, two segments of the chromatin band are arranged also in continuous loops. *Fig. 11*, from another sac of the same ovary, represents a strongly multipolar antipodal spindle, but with the chromatin band broken up into chromosomes; while *fig. 12*, the micropylar spindle from the same sac, shows a continuous looping of the chromatin band. The significance of these phenomena seems quite obscure, and their normal or abnormal character in the case of Lilium can only be ascertained by further investigation. If they represent a normal phase in the development of the bipolar spindle, their rarity would indicate either that it is a peculiarly ephemeral phase, or that it is not easily recognized. If they represent another method of spindle formation their exceptional occurrence might be easily accounted for; and the same may be said of the hypothesis that they represent spindles disorganized by sectioning or reagents. In these same figures (*figs. 9–12*) it will be noticed that the reagents used have brought out abundant striations in the cytoplasm, whose normal or abnormal character may be in question.

Various phases in the eight-nucleated stage of the embryo sac are represented by *figs. 13–16*. The varying directions of the spindles are evident, but in general the synergid spindle is transverse, and the spindles which give rise to the polar nuclei are longitudinal. It is plain that the synergids are sister nuclei, as are also the oosphere and the micropylar polar nucleus. It is also evident from the figures that if direct division occurs among the antipodal nuclei of Lilium our preparations give no evidence of it. An examination of Miss Sargent's figures,[2] which are cited as representing cases of direct division in the antipodal region of *L. Martagon*, shows that they might be taken for cases of mitosis.

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[2] Annals of Botany, **10**: 445–447. 1896.

In connection with the spindles of the embryo sac attention should be called to the fact that the spindle fibers thicken in the equatorial plane as if preparatory to the formation of a cell wall (*figs. 14, 15*). This phenomenon has been taken to be another evidence of the descent of this free-celled gametophyte from one of compact tissue.

The condition of things represented by *fig. 17* is difficult to interpret. While it is no unusual thing for a partition wall to be formed at the antipodal end of the sac, a wall at the micropylar end seems worthy of comment. If the nuclear division represented as just taking place is the first division of the definitive nucleus, which seems probable, the other nuclei are easily referred, and it would follow that the synergids are cut off from the oosphere (or oospore ?) by a wall.

In our preparations, the fusion of the polar nuclei is so commonly associated with the fusion of the sex cells (*fig. 19*) that the so-called "eight-celled" stage of the sac may be regarded as its ordinary ante-fertilization preparation. *Figs. 18* and *19* represent the fusion of polar nuclei, in the latter case but a small portion of the upper nucleus being shown.

PHENOMENA OF FERTILIZATION.

The pollen tube, as usual, passes between a synergid and the wall of the sac, and then bends more or less sharply towards the oosphere. Its enlarged caliber and more deeply staining contents are associated with the disorganization of the synergid with which it is in contact. If the pollen tube has been directed to the micropyle under the influence of chemotaxis, and the active principle of chemotaxis is a secretion from the synergids, it is interesting to observe that when the tube has reached and passed the synergids it is under the control of an influence powerful enough to bend it sharply towards the oosphere. If the hypothesis of chemotaxis and the origin of the attractive substance are true in this case, it would seem that it does not effect the essential contact, but brings the tube within the influence of another attraction which immediately directs it to the oosphere. The discharge of a male cell seems to be attended by disorganization and rupture of the tip of the tube (*figs. 19, 20, 24*), as observed by Schaffner in *Sagittaria variabilis*.[3] In *fig. 19* the second undischarged male cell may be seen in the end of the tube in a disintegrating condition; and *fig. 24* represents a case of a remarkably persistent tube and an undischarged male nucleus, the latter being distinctly nucleolated, as late as the second division of the embryo. The synergid not disorganized by the pollen tube persists for some time, as is usual, its nucleus being shown in *figs. 20, 22, 23*.

During fusion the sex nuclei hold no definite position in reference to each other, as is evident from *figs. 19–22*, where certain details concerning nucleoli and chromatin bands may also be noted. It is evident, thererefore, that the position of the fusing nuclei holds no relation to the plane of the first division of the oospore.

In *figs. 20* and *21* the structures figured by Guignard as centrospheres are represented. In these special cases no other structures in the cell bore any resemblance to them, but they were not seen except occasionally in connection with the nuclei in an advanced state of fusion. As no effort was made to demonstrate them, however, this testimony has no special significance. Their frequent association with nuclear phenomena in the higher plants certainly requires explanation, whether the current homology and function be established or not.

DEVELOPMENT OF THE EMBRYO.

Before division the oospore enlarges, elongates, and is not always axially attached to the sac wall (*fig. 23*). At the same time the nucleus enlarges and establishes itself at the free end of the cell. As a consequence, the first division, which is always transverse, results in a small apical cell and a comparatively large and somewhat vesicular basal cell. This basal cell and the subsequent basal region is worthy of remark, and will be noted later. After the first division there is no regular sequence of cell divisions. The second may occur in the basal cell, either transversely (*fig. 25*) or longitudinally (*fig. 24*). That a longitudinal division of the basal cell commonly occurs at some time is evidenced by the later stages of the embryo (*figs. 27–33*). Cell division continues in any region of the embryo and in every direction (*figs. 26–33*). It is impossible to formulate even a general sequence of events or to make any sharp distinction between suspensor and embryo. The amount of the whole embryonic structure which contributes to the completed embryo is variable, and such a thing as a distinctly defined suspensor which may "contribute" to the formation of the embryo does not exist. It would seem better to regard the so-called suspensor not as an organ distinct from the embryo, but rather as a region of the embryo, more or less extensive even in the same species, set apart to serve a temporary purpose. From this standpoint the question as to what the suspensor "contributes" to the embryo, and what the embryo "contributes" to the suspensor, becomes arbitrary and useless refinement. Like much physiological differentiation this may result in a structure externally distinct or it may not. The function of this region of the embryo seems to be to anchor, to absorb, and to relate the embryo properly to its food supply. Therefore, it displays the widest possible variation in extent and structure. The statement that certain plants have no suspensors may or may not be true, but this fact would seem to have no special morphological significance. It has seemed best to me to regard the suspensor not as a phylogenetic rudiment, but as a specialized structure of the embryo adapted to the peculiar conditions of intraseminal development.

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[3] Bot. Gaz. 23: 256. 1897.

The tendency of the basal region of the embryo to spread widely as an absorbent organ in contact with the wall of the sac is very noticeable (*figs. 26–32*). An extreme case at an early stage is represented by *fig. 29*, but cases of still more extensive lateral extension were observed, very suggestive of certain reported cases of apogamous polyembryony from the nucellar tissue just above the embryo sac. In *fig. 32*, the most mature embryo represented, a distinct development of tissue in the suspensor region is shown, which appears late in the development of the embryo, and is well marked off from the embryo proper by a narrow neck. This suspensor tissue is erythrophilous as compared with the embryo, showing its closer relation to nutritive supplies. From this late development of tissue in the suspensor region, and its great activity, it would suggest its possible association with supposed cases of polyembryony.

DEVELOPMENT OF ENDOSPERM.

It is becoming well known that the first division of the definitive nucleus holds no direct relation to the fusion of the sexual nuclei. It may precede or follow this fusion, or be coincident with it. So far as observed it occurs after the entrance of the pollen tube into the sac, but at almost any time thereafter, apparently related to no special one of those events which follow and which go to make up the process of fertilization. It seems reasonable to suppose that the inciting event is the entrance of the tube. In the case of Lilium the sexual and polar pairs of nuclei were observed to fuse simultaneously, but when division begins the endosperm nuclei divide more rapidly than do the cells of the embryo. When the embryo is but two or three-celled numerous free endosperm nuclei are scattered throughout the embryo sac (*fig. 35*). Later cell walls begin to form in the endosperm. A very interesting phase in the division of the definitive nucleus is shown in *fig. 34*. The remarkably distinct radiations about the forming daughter nuclei seem to be due to the spindle fibers pulled apart, and to other radiations which are similar to those which appear about the forming daughter nuclei in the divisions of the nuclei of the embryo sac which precede fertilization. Such radiations are difficult to interpret, but their distinctness in this preparation could not be exaggerated.

During the development of the embryo and endosperm the embryo sac enlarges rapidly except at the antipodal end, which is left as a sort of caecum, often thrust to one side, in which may be seen the disintegrating antipodal nuclei (*fig. 35*). Around the narrowed antipodal end of the sac there is developed a very heavy wall, which in itself would seem to be a sufficient reason for the failure of that region of the sac to enlarge.

EXPLANATION OF PLATES XXXII–XXXIV.

The figures are reduced from drawings to about three-eighths of their original size. The combination of objective and ocular is indicated in each case, the initial letters indicating Zeiss, Leitz, Reichert, and Bausch and Lomb. The four combinations used and their magnification in diameters were $R\frac{1}{7}$ R4, 760; B & $L\frac{1}{12}$ immersion R4, 1200; $Z\frac{1}{12}$ immersion L4; $Z\frac{1}{12}$ immersion Z18, 2250. All the figures are from *Lilium Philadelphicum* unless otherwise indicated.

FIG. 1. Tip of nucellus with the single archesporial cell which develops directly into the macrospore. B & $L\frac{1}{12}$ R4.

FIG. 2. First division of the macrospore nucleus, showing radiations about the daughter nuclei, and thickening of spindle fibers in the equatorial region. $Z\frac{1}{12}$ L4.

FIG. 3. Daughter nucleus of the first division at an earlier stage, showing relation of micronucleoli to radiations. $Z\frac{1}{12}$ Z18. Iron alum.

FIG. 4. Spindles of the second nuclear division of the macrospore, showing transverse axis and reduction number of chromosomes of micropylar spindle, and longitudinal axis and increased chromatin mass of the antipodal spindle. $Z\frac{1}{12}$ L4. Iron alum.

FIG. 5. Spindles of the second division. $Z\frac{1}{12}$ L4. Iron alum.

FIG. 6. The four nuclei of the second division completed. $Z\frac{1}{12}$ L4.

FIGS. 7–7*a*. The four nuclei, showing persistence of spindle fibers and shifting of nuclei. B & $L\frac{1}{12}$ R4.

FIG. 8. The four nuclei much shifted. B & $L\frac{1}{12}$ R4.

FIG. 9. An unusual antipodal spindle, showing several poles and continuous looping of chromatin band. $Z\frac{1}{12}$ Z18. Iron alum.

FIG. 10. The micropylar spindle of the same sac, showing several poles and two masses of continuous looped chromatin band. $Z\frac{1}{12}$ Z18. Iron alum.

FIG. 11. An antipodal spindle with numerous poles. $Z\frac{1}{12}$ Z18. Iron alum erythrosin.

FIG. 12. Micropylar spindle of same sac, showing several poles and a continuous looping of the chromatin band. $Z\frac{1}{12}$ Z18. Iron alum erythrosin.

FIG. 13. Spindles of the third nuclear division, showing transverse synergid spindle, longitudinal polar nuclei spindles, and an antipodal spindle. Z$\frac{1}{12}$ L4.

FIG. 14. Same stage, with radiations more evident, equatorial thickening, and a very evident antipodal spindle. Z$\frac{1}{12}$ L4.

FIG. 15. Same stage further advanced. Z$\frac{1}{12}$ L4.

FIG. 16. Completed eight-celled stage. R$\frac{1}{7}$ R4.

FIG. 17. Embryo sac, showing wall at antipodal and micropylar ends, the latter cutting off the synergids, the former one antipodal cell, and the definitive nucleus dividing. B & L$\frac{1}{12}$ R4.

FIG. 18. *L. tigrinum;* polar nuclei fusing. B & L$\frac{1}{12}$ R4.

FIG. 19. *L. tigrinum;* pollen tube with the second male nucleus disintegrating and the tip of the tube ruptured; fusing sex nuclei, the male uppermost; fusing polar nuclei, but the small part of the upper one showing. B & L$\frac{1}{12}$ R4.

FIG. 20. *L. tigrinum;* pollen tube bent sharply towards oosphere, with disorganized tip, the nucleus near its tip being that of persistent synergid; fusing sex nuclei, the male on the left. B & L$\frac{1}{12}$ R4.

FIG. 21. Fusing sex nuclei, with paired centrosomes. B & L$\frac{1}{12}$ R4.

FIG. 22. *L. tigrinum;* fusion of sex nuclei about completed; persistent synergid nucleus above. B & L$\frac{1}{12}$ R4.

FIG. 23. Oospore with broad basal attachment, and the fusion nucleus in apical position; nucleus of persistent synergid still visible. B & L$\frac{1}{12}$ R4.

FIG. 24. Young embryo, showing first division transverse, second division basal and longitudinal; pollen tube with ruptured tip and a remarkably persistent male nucleus. B & L$\frac{1}{12}$ R4.

FIG. 25. Same, but second division transverse. B & L$\frac{1}{12}$ R4.

FIGS. 26–30. Young embryos, showing various phases of division and the broadened basal region. B & L$\frac{1}{12}$ R4.

FIGS. 31–32. More advanced embryos. B & L$\frac{1}{12}$ R4.

FIG. 33. Advanced embryo, showing development of the suspensor region which is separated by a narrow neck from the embryo proper. R$\frac{1}{7}$ R4.

FIG. 34. *L. tigrinum.* First division of definitive nucleus, showing remarkably prominent radiations about the daughter nuclei. B & L$\frac{1}{12}$ R4. Safranin and gentian violet.

FIG. 35. Embryo sac, showing free endosperm nuclei, the caecum-like antipodal end of the sac containing the three disorganizing antipodal nuclei, and a three-celled embryo. R$\frac{1}{7}$ R4.

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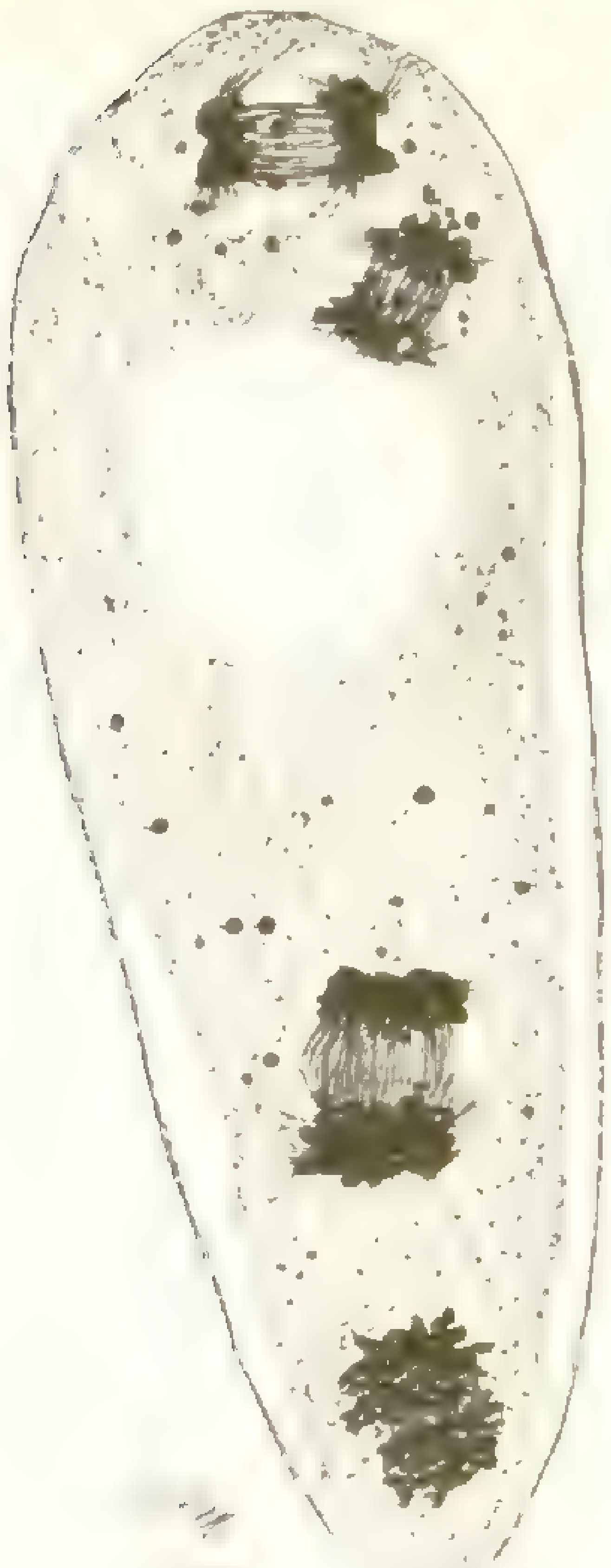
COULTER on LILIUM.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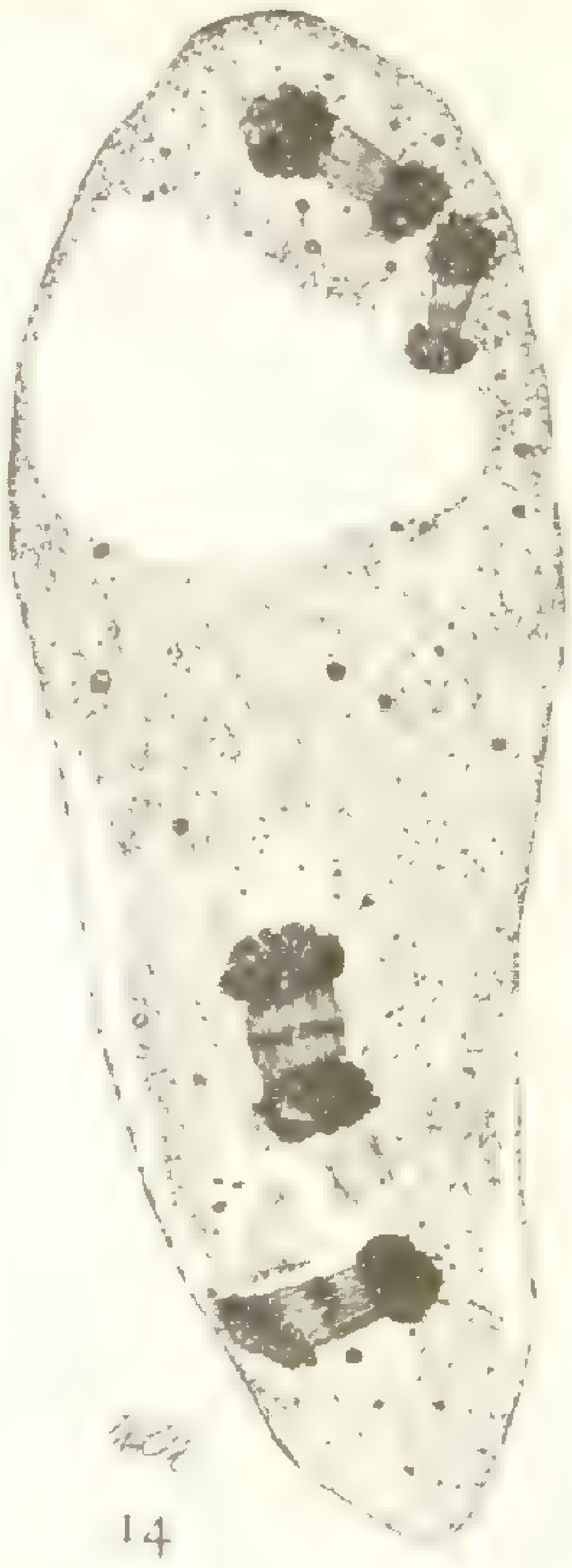
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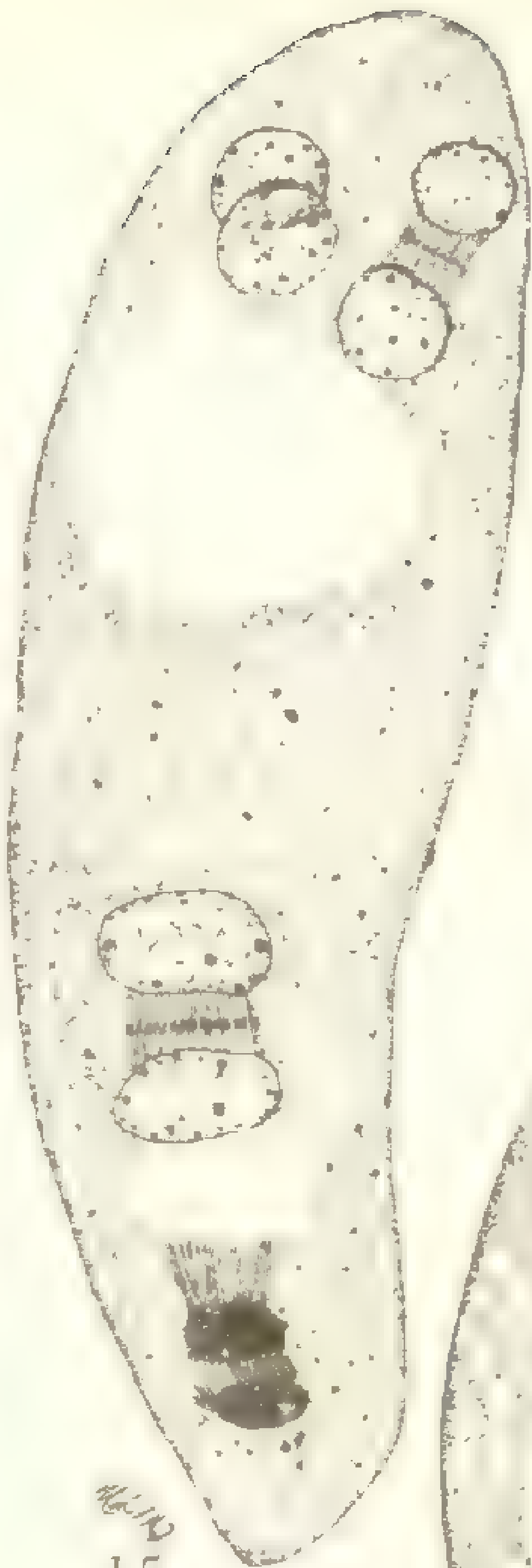
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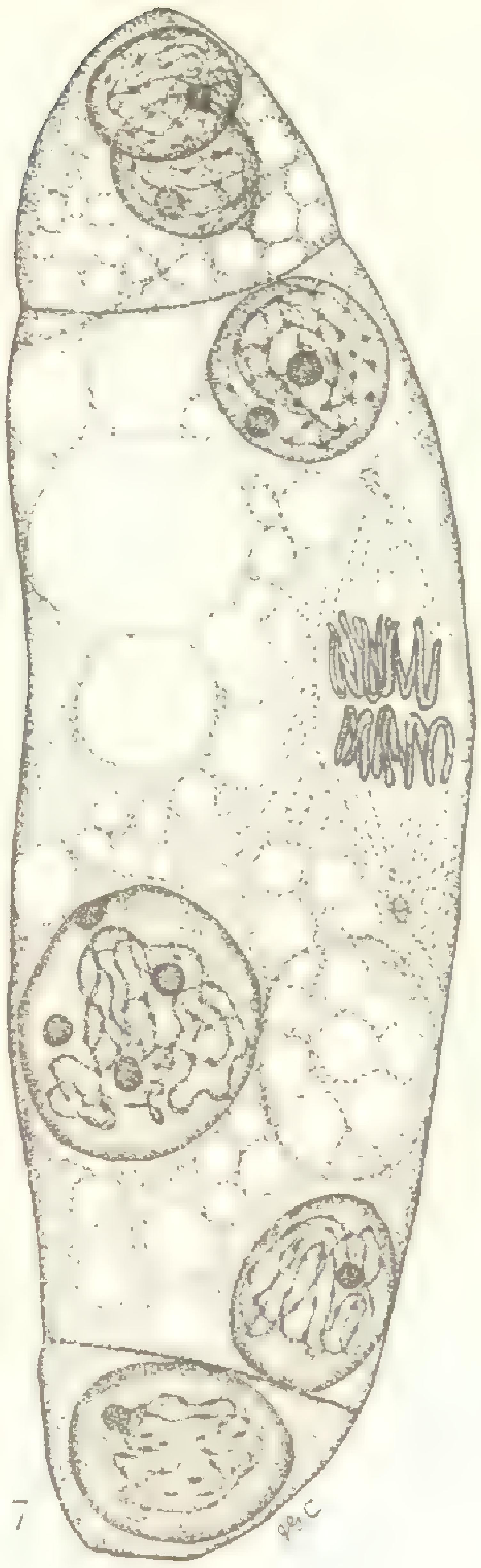
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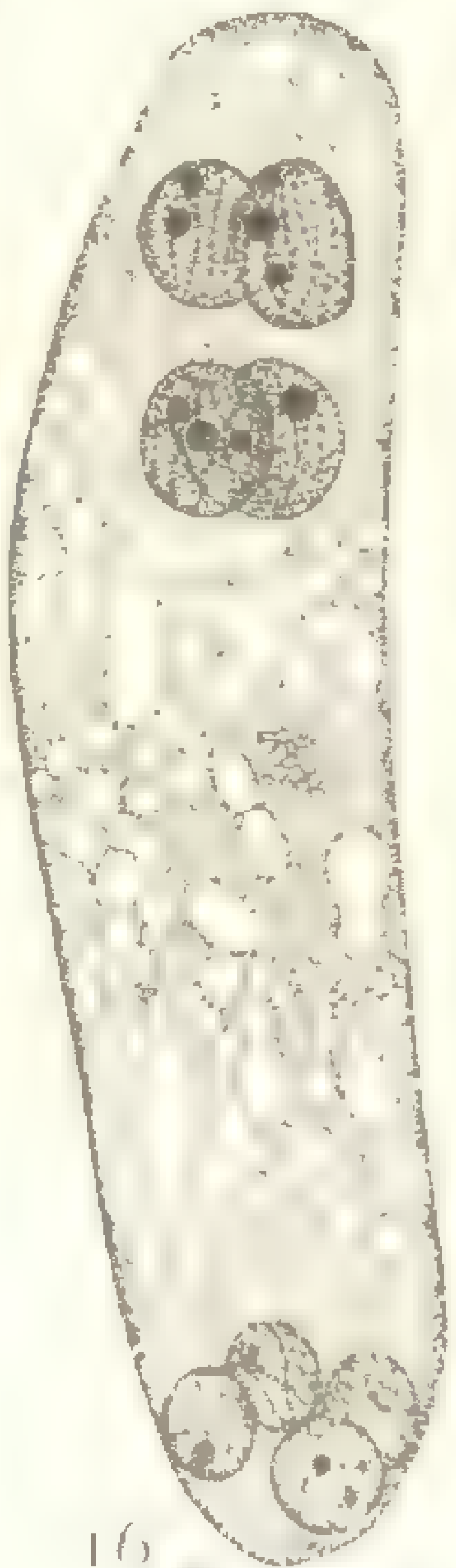
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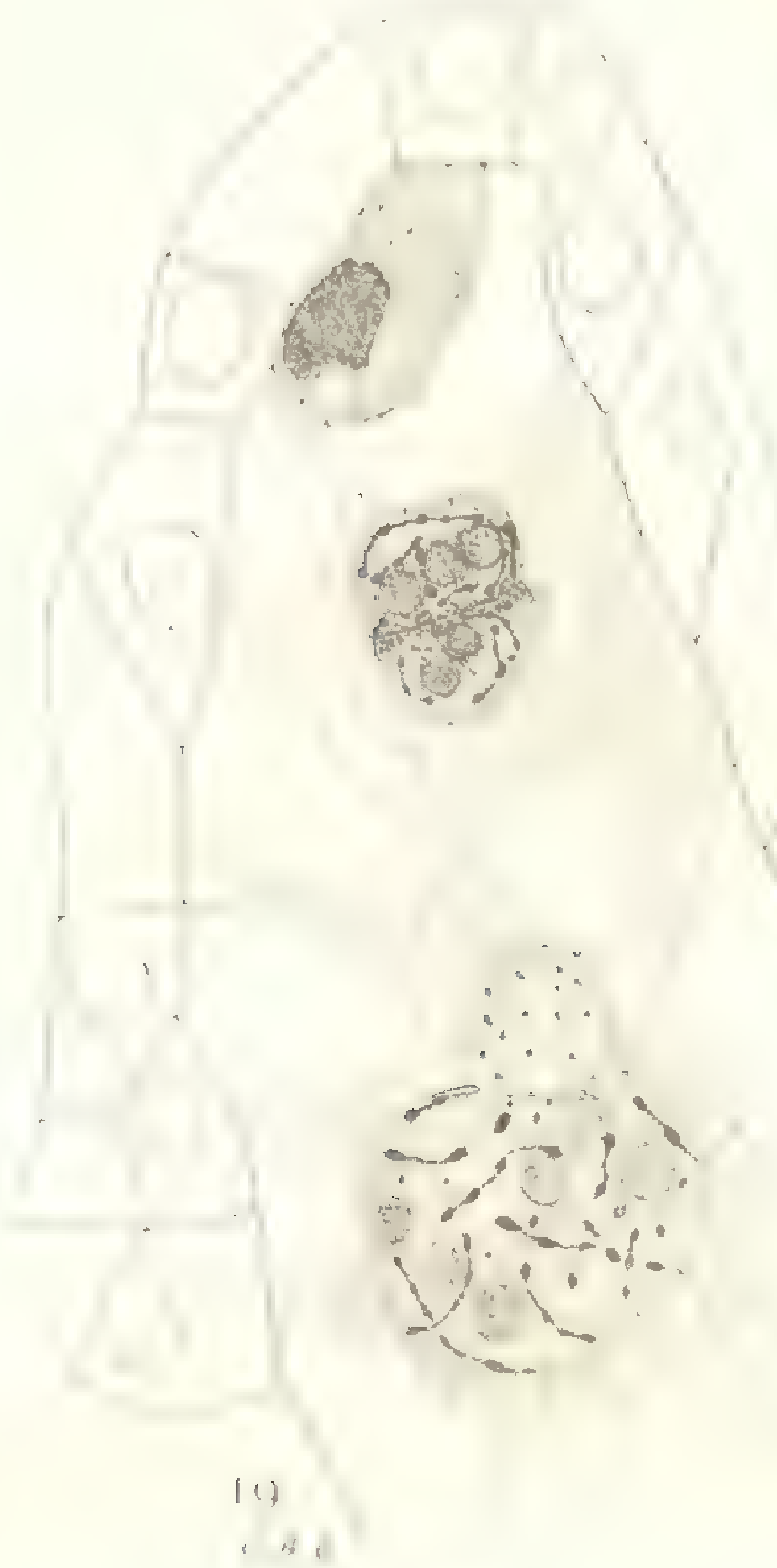
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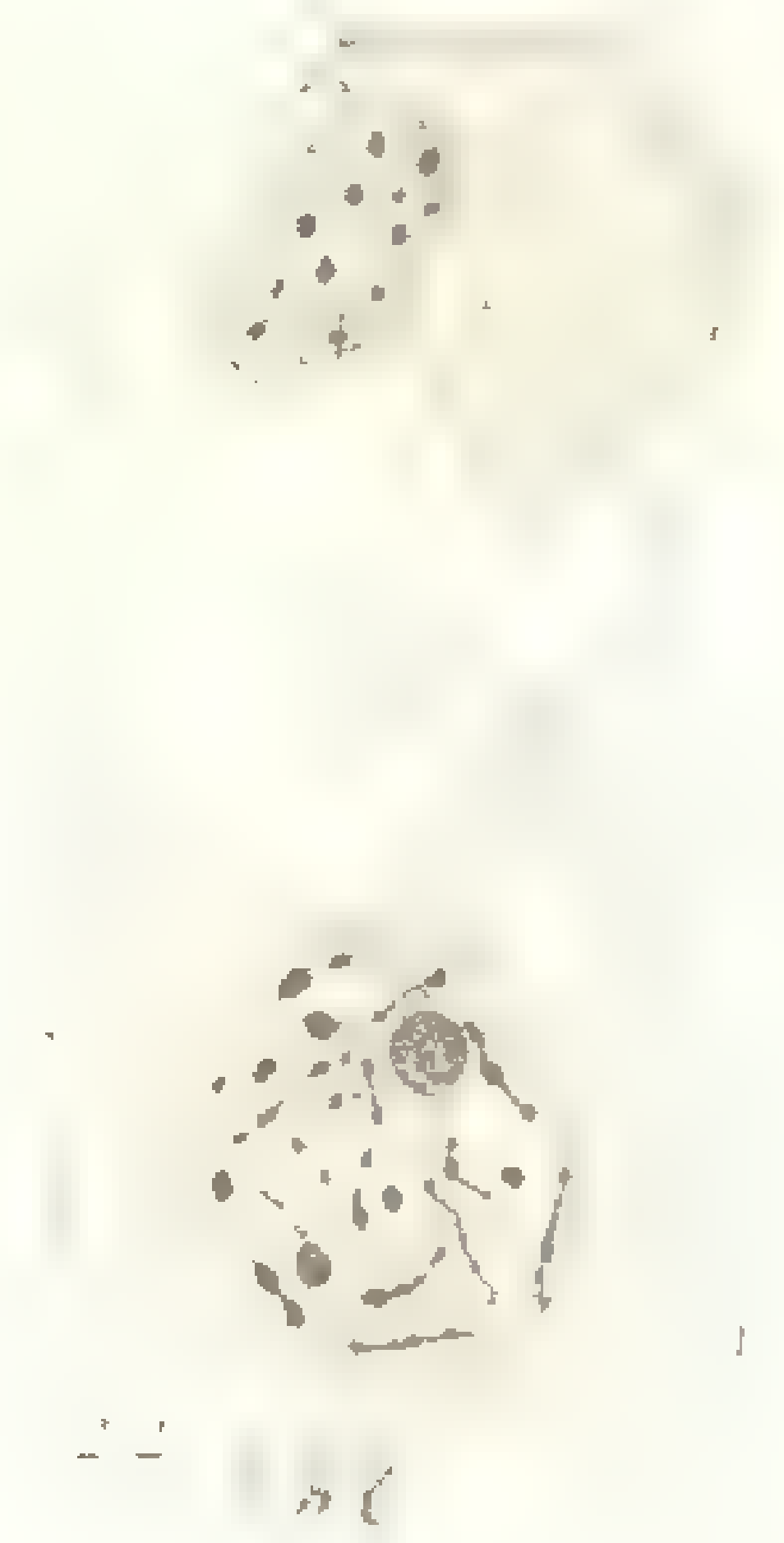
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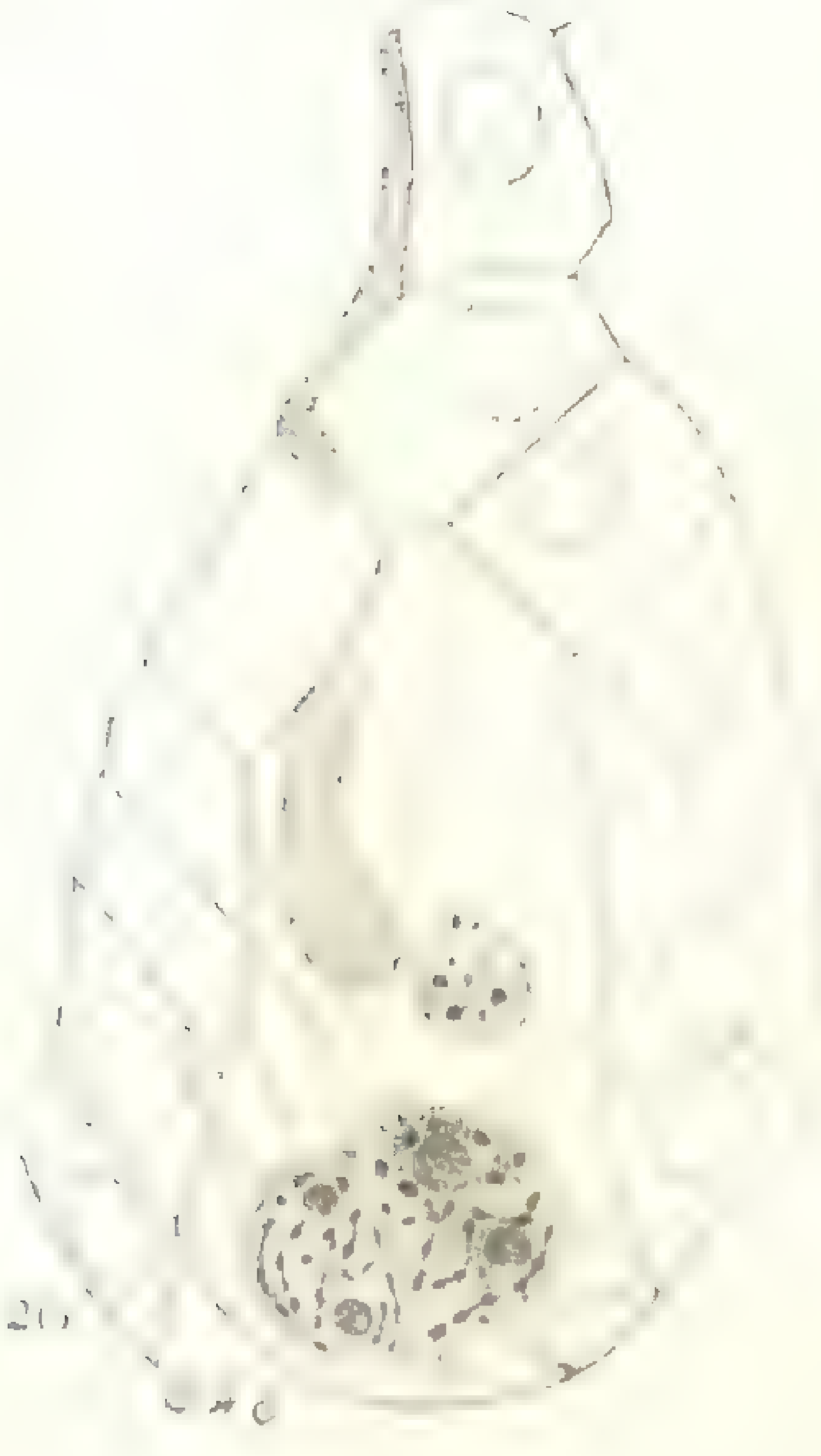
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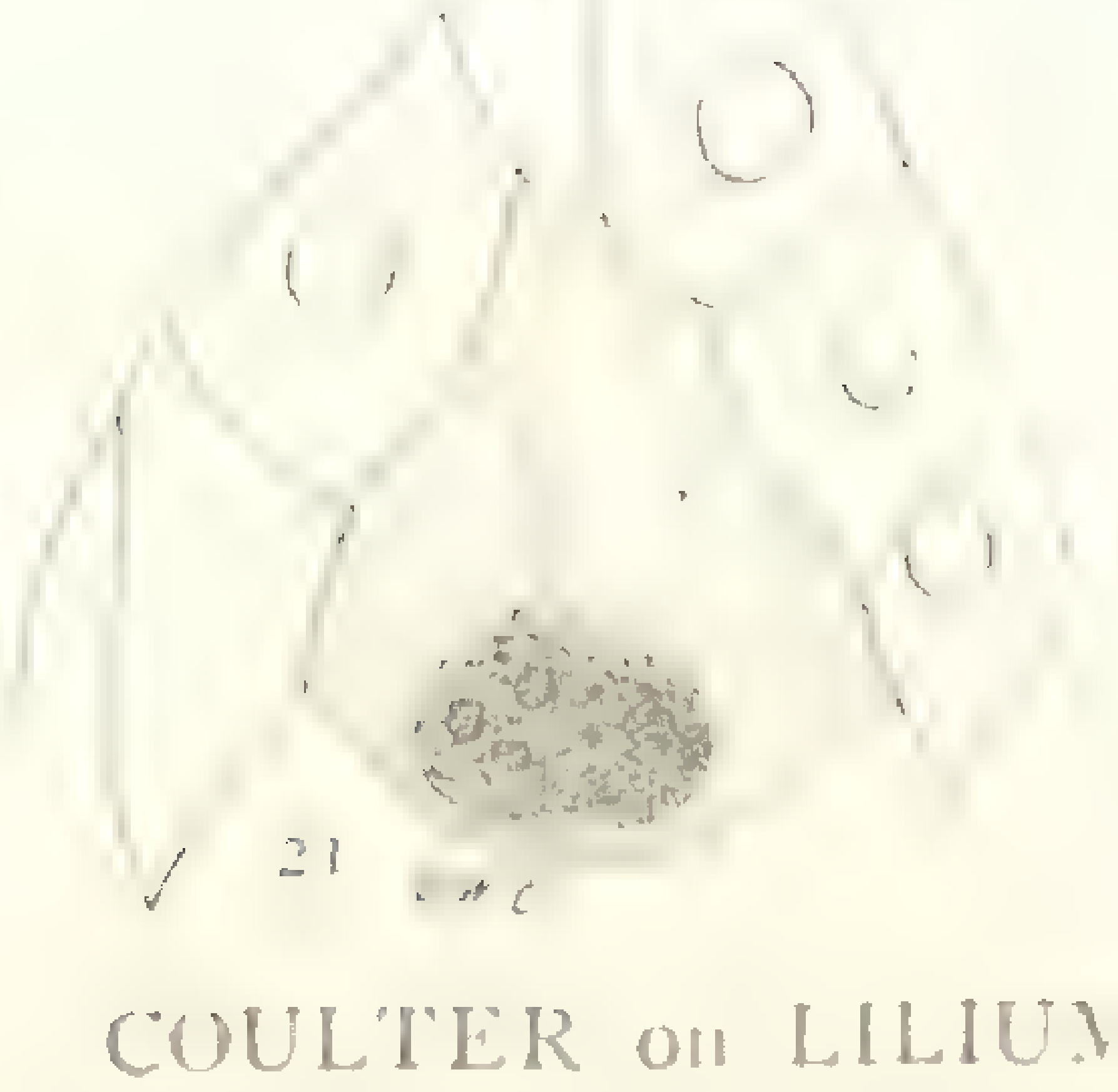
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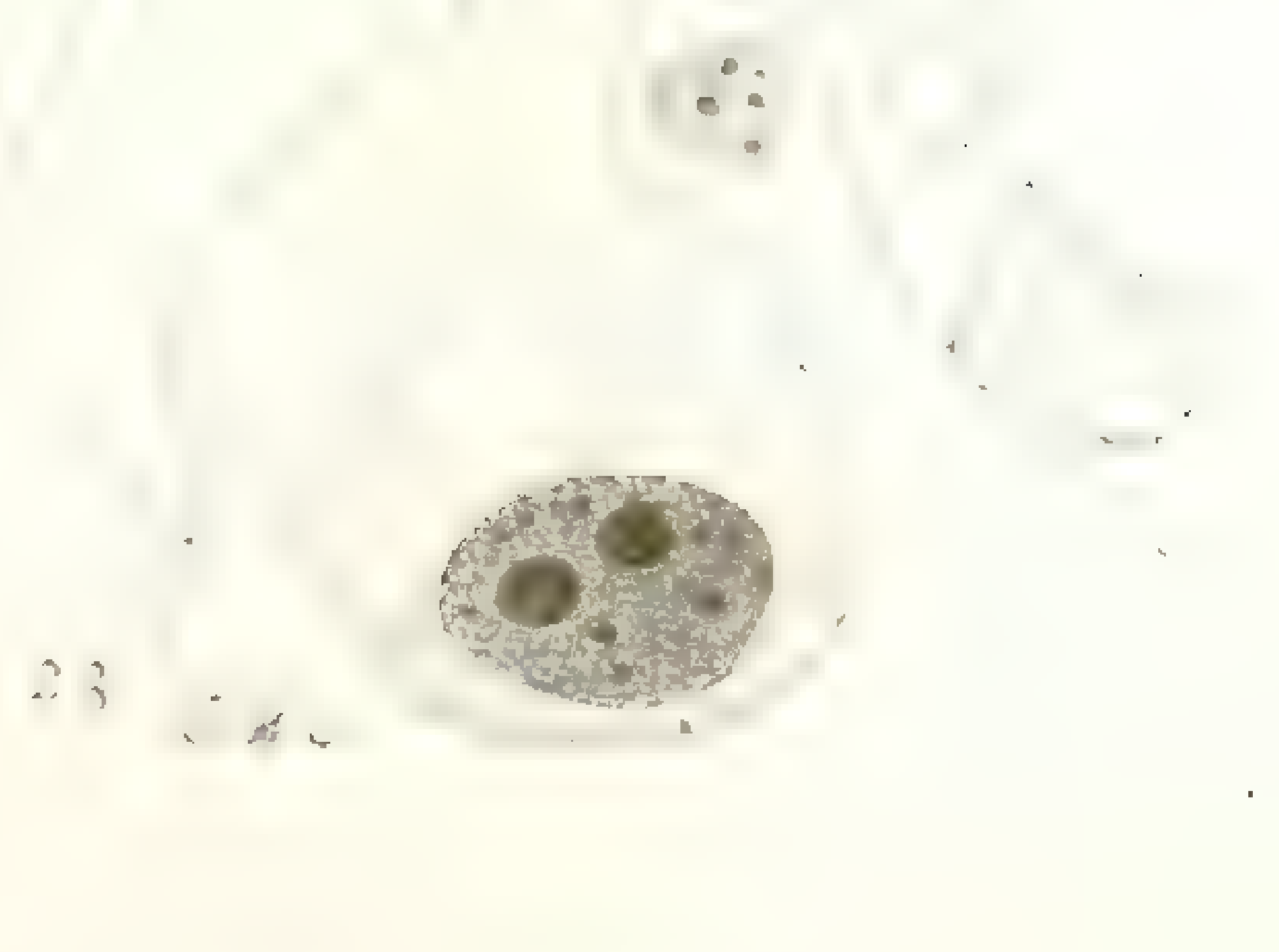
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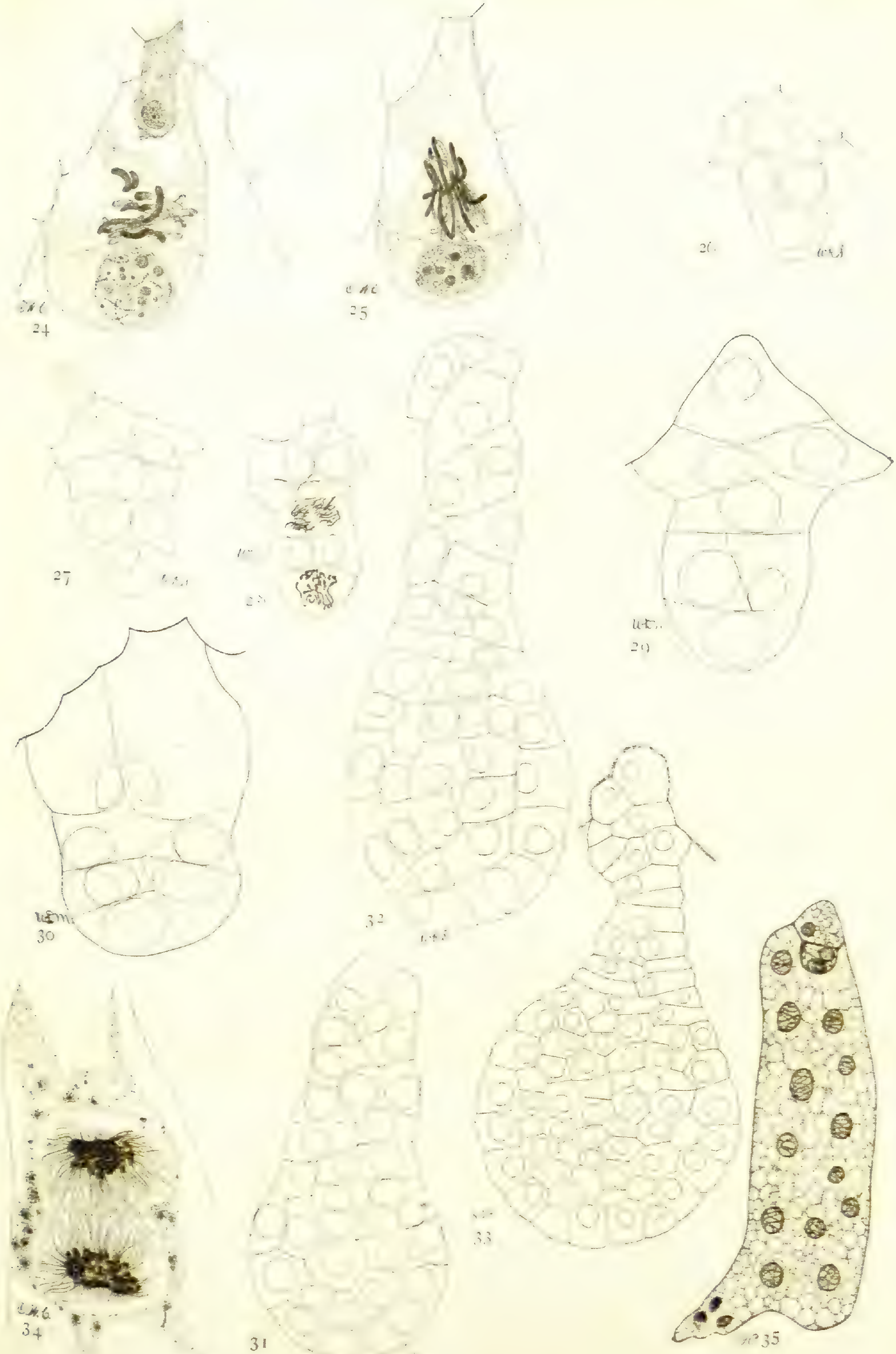
COULTER on LILIUM.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COULTER on LILIUM.

II.

THE POLLEN GRAIN.

CHARLES J. CHAMBERLAIN.

(WITH PLATES XXXV–XXXVI)

It is not my purpose to treat this subject in any detail, but merely to note a few of the more essential and critical points. Thanks are due to Professor Coulter for his criticism, and to many advanced students in the laboratory for the privilege of examining several hundred preparations.

HISTORICAL.

During the past thirty years the embryo sac of spermatophytes has received large attention, and its main structures have been figured and described in many species, but the pollen grains, which are of equal importance, have received but scant attention. The most important literature has been furnished by Hartig, Elfving, Dixon, Guignard, Farmer, and Belajeff. Hartig was the first to describe two nuclei in the ripe pollen grain. Strasburger (1884) greatly extended the researches and described the pollen grains of a great variety of species representing the principal groups of angiosperms and gymnosperms. He showed that the smaller of the two cells in the ripe spore is the generative, also that the generative nucleus undergoes division, giving rise to two male nuclei. This division usually takes place in the pollen tube, but in many cases it takes place in the spore, so that the mature spore may contain three nuclei. Elfving saw three male nuclei in the mature spore of *Andropogon campestris*. Strasburger (1884) reports the occurrence of four male nuclei in the pollen tubes of Ornithogalum and Scilla Guignard (1891) says that in *Lilium Martagon* the division of the generative nucleus occurs only in the pollen tube, and that the tube nucleus never divides at all. Strasburger (1884) also makes the general statement that the tube nucleus never divides.

As long ago as 1884 Strasburger discovered that with a fuchsin-iodine-green mixture the generative nuclei of pollen grains stain green, and the tube nuclei red; but more recently (1892) he has discussed quite thoroughly the staining reactions of the nuclei. The nuclei of the small prothallial cells of gymnosperm microspores are cyanophilous, like generative nuclei. The nuclei of the nucellus surrounding the embryo sac are also cyanophilous. His conclusion is that the cyanophilous condition in both cases is due to poor nutrition of the nuclei, the amount of cytoplasm being small in proportion to the size of the nuclei. On the other hand, the erythrophilous condition of the nuclei of the embryo sac is due to abundant nutrition. As a further proof of the theory it is noted that the nuclei of the adventitious embryos which come from the nucellus of *Funkia ovata* are decidedly erythrophilous, while the nucellus to which they owe their food supply has cyanophilous nuclei.

In division stages nuclei are cyanophilous. From anaphase to resting stage cytoplasm is taken into the nucleus and the cyanophilous condition gradually changes to the erythrophilous, but when a nucleus is prevented from taking nutrition from a large amount of cytoplasm, as is the case with generative nuclei of pollen grains and the nuclei of the small prothallial cells of gymnosperms, the reaction remains cyanophilous. It is an added proof, that in Ephedra the tube nucleus, which has very little cytoplasm about it, is cyanophilous. Strasburger claims that there is no essential difference between the male and female generative nuclei, and observation shows that within the oosphere spermatozoids and other male generative nuclei become erythrophilous, so that the sex nuclei are alike in their reaction to stains. Malfatti and Lilienfeld have proved that these reactions are dependent upon the amount of nucleic acid. Chromosomes during mitosis consist of nearly pure nucleic acid and are intensely cyanophilous; while cytoplasm has little or no nucleic acid and is erythrophilous. There are all gradations between the cyanophilous and erythrophilous conditions, the affinity for basic anilines being in proportion to the amount of nucleic acid.

It is unfortunate that the terms cyanophilous and erythrophilous are becoming established, since the affinity is for basic or acid dyes, and not for blue or red colors. That the terms are misnomers becomes evident when a combination like safranin (basic) and acid green (acid) is used, for the cyanophilous structures take the red, and the erythrophilous the green.

THE MOTHER CELLS AND TETRADS.

Fairly complete series were obtained in *L. tigrinum* and *L. Philadelphicum*, but since the two species showed very similar results only *L. tigrinum* is described.

The mother cell develops its tetrads after the usual manner among monocotyledons. It was my original purpose to make a cytological study of these cells, chiefly with reference to the phenomena involved in the "reduction division," but my attention was diverted to certain structures of the mature spore, which will be hereafter described. However, certain cytological notes obtained may be of interest.

The nuclei of the mother cells in early spirem stages show a single much twisted ribbon with a row of chromatin granules on each edge. In many cases it could be seen that the chromatin granules were arranged in opposite pairs (*figs, 1 and 1a*). These pairs are separated by a longer stretch of ribbon than is figured by Guignard in his description of *L. Martagon*. The granules are usually more or less ellipsoidal in shape, the longer axis coinciding with that of the ribbon. With cyanin and erythrosin the ribbon stains red, and the granules blue. The ribbon splits longitudinally throughout its entire length before it segments into chromosomes (*fig. 1*). The nuclei showed twelve segments of this double thread in all cases in which the number was definitely ascertained. The further history of the chromosomes and the formation of the spindle were not followed.

In the tetrad stage the nuclear thread is not nearly so intricate, and is often spirally wound inside the nucleus. somewhat like a chromatophore of Spirogyra (*fig. 2.*) In many cases it seemed as if even in spirem stages the position of the future spindle could be predicted. Centrospheres were observed both in the mother cell and tetrad stages.

THE MATURE SPORE.

The microspore usually reaches its full size and the exine acquires its characteristic markings before its nucleus divides. During the growth which precedes this division the nucleus remains approximately in the center of the cell, but just before the division it often moves toward one end of the spore (*fig. 4*). The position of the nuclei, however, often indicates that division has taken place without any such preliminary movement (*fig. 5*). Nearly all the mature microspores of *L. tigrinum* present essentially the conditions represented in *figs. 5* and *6*. The tube nucleus is larger and erythrophilous, while the generative nucleus is cyanophilous. The number and size of nucleoli vary, but as a rule the nucleoli of the tube nucleus are larger than those of the generative nucleus. The chromatin network of the tube nucleus is much finer and more irregular than that of the generative nucleus.

Such cases as *figs. 6–8* are common, and they give the impression that a wall is separating the generative and tube cells. When the generative cell is lenticular and pressed against the wall of the spore it is usually at one end (*fig. 6*), but occasionally it is at one side (*fig. 7*). The cytoplasm of the generative cell was entirely free from starch except in one instance.

Centrospheres were observed in connection with both the tube and generative nuclei. It is comparatively easy to demonstrate centrospheres with the generative nucleus on account of the uniformity in their position and the small amount of cytoplasm in the generative cell. The tube cell is richly supplied with starch, which differs greatly in appearance as different stains are used.

The foregoing applies to most of the pollen grains of the species studied, but occasionally an anther was found which showed very different conditions. The most common variation was the division of the generative nucleus while still within the pollen grain (*figs. 8, 9*), a condition not uncommon in monocotyledons. More than a hundred such cases were noted in *L. tigrinum*, and about thirty in *L. auratum*, but they are rare in *L. Philadelphicum*. In two cases in *L. auratum* a further division of the generative nucleus was observed, resulting in three male cells (*fig. 10*).

There is abundant negative testimony for the usual statement that the tube nucleus never divides, but hundreds of pollen grains of *L. tigrinum* and *L. auratum* presented such division. In *fig. 12* there are four nuclei, all of which have the characteristics of tube nuclei. One pollen grain was found with eight nuclei, six of which were vegetative and two generative (*fig. 15*). Numerous cases like *figs. 3, 13* and *14* prove that this division is of the direct or amitotic type.

It may be noted in this connection that the cells of the tapetum often contain two, three, or even four nuclei which have been produced by the direct process. No evidence of mitosis was observed in the cells of the tapetum or in connection with the tube nucleus, but it is possible that it occurs in both cases, and that these nuclei may divide by either process. The significance of amitosis seems to be little understood in either animals or plants. The frequency of the phenomenon in pathological tissues has led to the theory that it is due to degeneration. On the other hand, such cases as the internodes of the Characeae suggest that it aids metabolism by increasing the nuclear surface. Its occurrence in gland cells connects it with extreme cell activity. If all cases of amitosis are to have the same explanation it must be much more inclusive than any of these suggested. In Lilium a single tube nucleus seems to suffice in the vast majority of cases. If amitosis is a degenerate condition from mitosis, the division of the tube nucleus might have a phylogenetic significance.

The pollen grains of *L. tigrinum* often showed another variation which seems to be quite important. In *fig. 17*, in addition to the tube and generative nuclei, there is shown a small cell cut off from the end of the spore. A similar condition is seen in *fig. 16*, but here the generative cell has effected its ordinary divisions. Over twenty such cases were observed. I have called the cell nuclei marked *g* (*figs. 16, 18*) male nuclei, that is, daughter nuclei from the generative nucleus, because their nucleoli are small, their chromatin network coarse, and in staining they are cyanophilous, that is, they show a preference for basic dyes. Besides, some of these nuclei are surrounded by definite areas of cytoplasm devoid of starch, indicating the organization of the male cell. The tube nucleus, or the several nuclei to which it may give rise, has larger nucleoli, finer chromatin network, and is uniformly erythrophilous. Hence it seems safe to conclude that the nuclei marked *g* in *figs. 16, 18* are generative in origin, and not vegetative like the tube nucleus and its derivatives. The small cell marked *pr* (*figs. 16, 18*) is hard to interpret. Its nucleus is cyanophilous, and its cytoplasm is free from starch. In these respects it resembles the generative nucleus and its derivatives, and if the tube nucleus were the only other nucleus in the spore I should call the small cell a much reduced generative cell. However, a study of all the cases discovered leads me to suggest that the small cell is a prothallial cell, homologous with the single prothallial cell of heterosporous pteridophytes. The small cell cut off from the microspore of *Populus monilifera*, figured but not described in my paper on Salix, adds probability to this hypothesis. If this interpretation is correct, it supports the view that the whole spore development, as it ordinarily appears, is an antheridium. In this case the tube nucleus and its cytoplasm is probably the homologue of the wall cells of such an antheridium as that of Isoetes; the pollen tube would become an outgrowth from the antheridium wall; and the two male cells would homologize with the spermatozoid mother cells. At least it seems out of the question to speak of the pollen tube as the male gametophyte.

Another peculiar phenomenon was noted in *L. tigrinum*. In about twenty cases there was a distinct wall dividing the microspore into two nearly equal parts (*figs. 19-20*). Both cells contained starch, and when each cell contained but one nucleus they stained alike. In *fig. 20* one of the cells contains two nuclei which seem to represent generative and tube nuclei, and two other such cases were observed. In these cases, also, I am inclined to regard one of the cells as prothallial, and the other antheridial.

EXPLANATION OF PLATES XXXV–XXXVI.

All figures, except *fig. 1 a*, were drawn with an Abbe camera lucida, $\frac{1}{12}$ Bausch and Lomb immersion, and Zeiss ocular 4. The combination gives a magnification of 1010 diameters. *Fig. 1 a* was drawn with $\frac{1}{12}$ Bausch and Lomb, ocular 18 Zeiss. The drawings are reduced one-half by photography: *g*, generative nucleus, *pr*, prothallial cell. *Figs. 3, 9, 10* are from *L. auratum*, all others from *L. tigrinum*.

FIG. 1. Mother cell of pollen grain; the ribbon splitting longitudinally.

FIG. 1 *a*. Small portion of ribbon showing usual shape and position of chromatin granules. Cyanin and erythrosin.

FIG. 2. Young pollen grain from tetrad, showing centrosomes and spiral arrangement of ribbon.

FIG. 3. Mature pollen grain with two tube nuclei and two generative nuclei; one of the tube nuclei suggests direct division.

FIG. 4. Division of primary nucleus of the pollen grain.

FIG. 5. Generative nucleus accompanied by centrosomes; starch quite conspicuous.

FIG. 6. Very common position of generative cell.

FIG. 7. Less common position of generative cell.

FIG. 8. Generative nucleus divided.

FIG. 9. Generative nuclei divided; one generative nucleus and the tube nucleus accompanied by centrosomes.

FIG. 10. Three generative nuclei.

FIG. 11. Tube nucleus divided.

FIG. 12. Four nuclei, all with characters of tube nuclei.

FIG. 13. Three nuclei, two of which indicate direct division.

FIG. 14. Two tube nuclei and one generative nucleus; one of the tube nuclei shows direct division.

FIG. 15. Six tube nuclei and two generative nuclei.

FIG. 16. One tube nucleus, two generative nuclei, and a prothallial cell.

FIGS. 17–18. One tube nucleus, one generative nucleus, and a prothallial cell.

FIG. 19. A definite wall separating the spore into two approximately equal parts.

FIG. 20. Same as preceding, but one part showing what may be interpreted as a generative nucleus and a tube nucleus.

III.

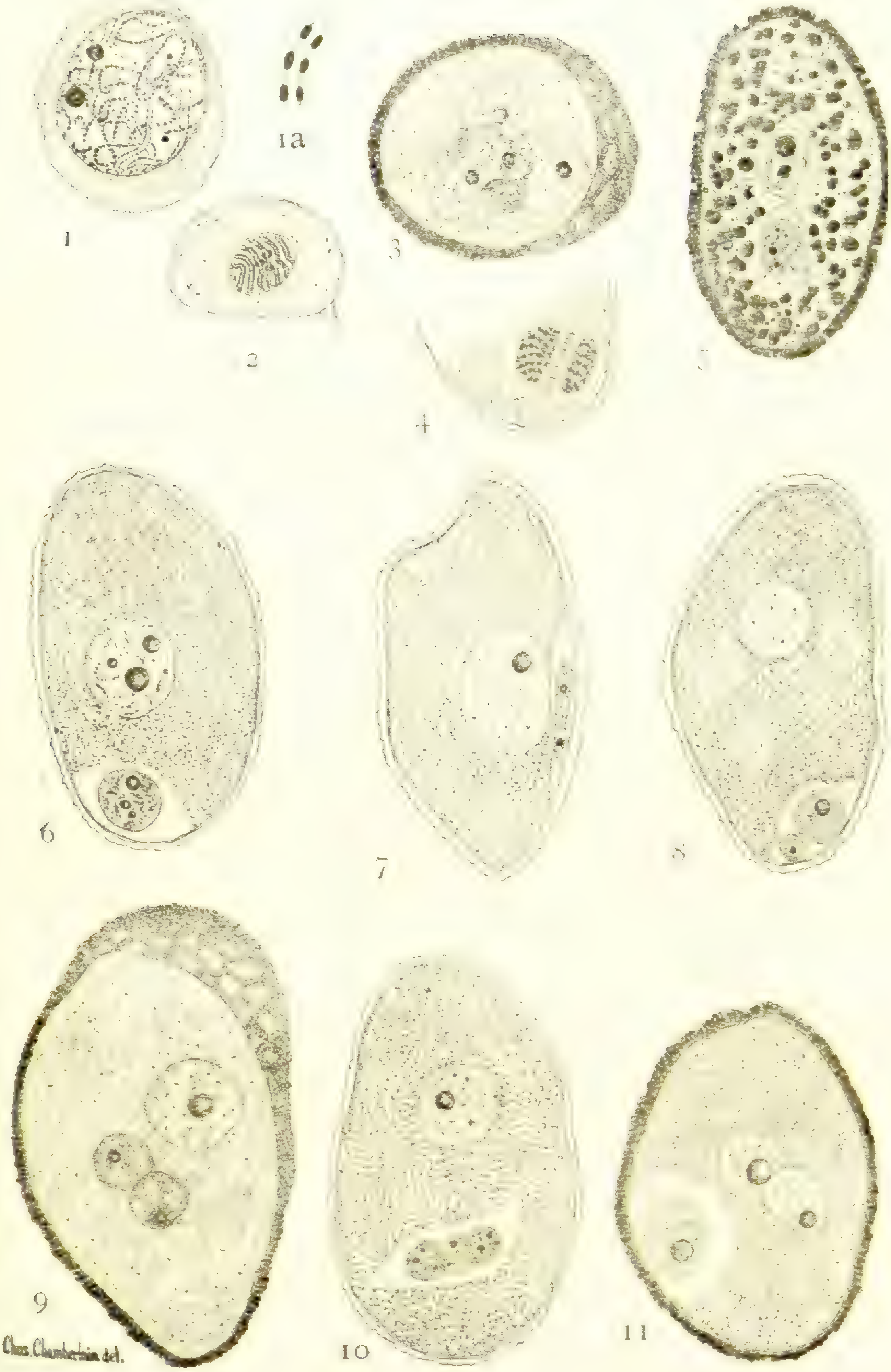
THE DIVISION OF THE MACROSPORE NUCLEUS.

JOHN H. SCHAFFNER.

(WITH PLATES XXXVII–XXXIX)

Although a knowledge of the changes which take place in the reduction nuclei of plants and animals is of the utmost importance, and will no doubt aid more than anything else in bringing about a correct interpretation of the facts of heredity, comparatively little has been done in this field, and the observations that have been reported disagree widely. This may be accounted for because of the extreme difficulty of properly preparing suitable material for study, and of correct observation and interpretation of the minute structures concerned. The following work was undertaken because especially favorable material was at hand, and some peculiar variations from what has been received as the normal process of reduction were observed. During the course of the investigation the writer was compelled several times to abandon preconceived notions obtained from the literature of the subject. Whatever, therefore, is presented in regard to the formation of chromosomes and the activities of the nucleoli during karyokinesis has not been the outcome of an attempt to establish evidence which would be agreeable to some hypothesis, but the whole investigation presented an array of facts conclusive to the writer's mind.

My thanks are due to Dr. John M. Coulter for his interest and supervision, as well as to a considerable number of coworkers in the laboratory who kindly permitted me to study and compare their preparations with my own.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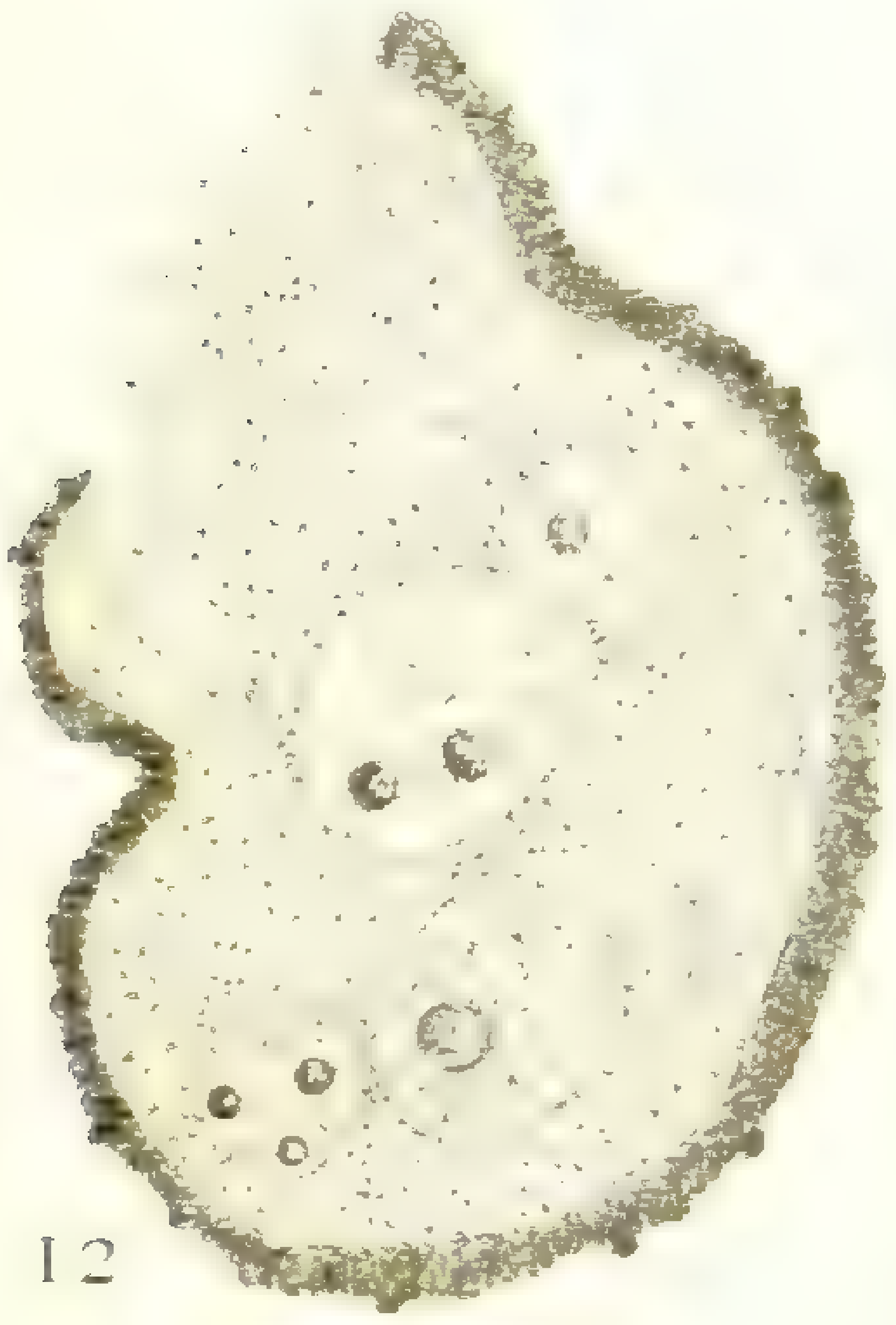
Chas. Chamberlain del.

CHAMBERLAIN on LILIUM.



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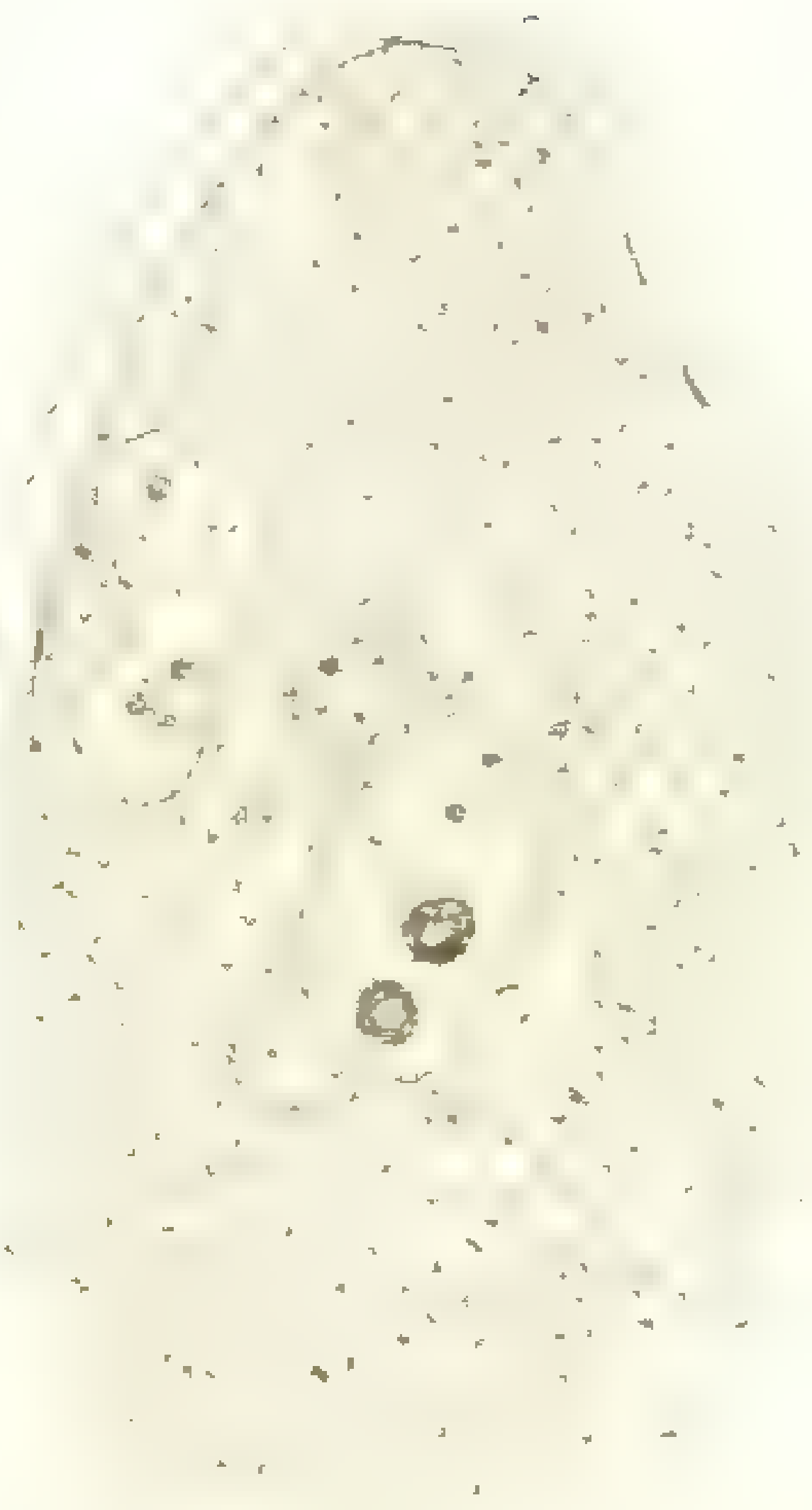

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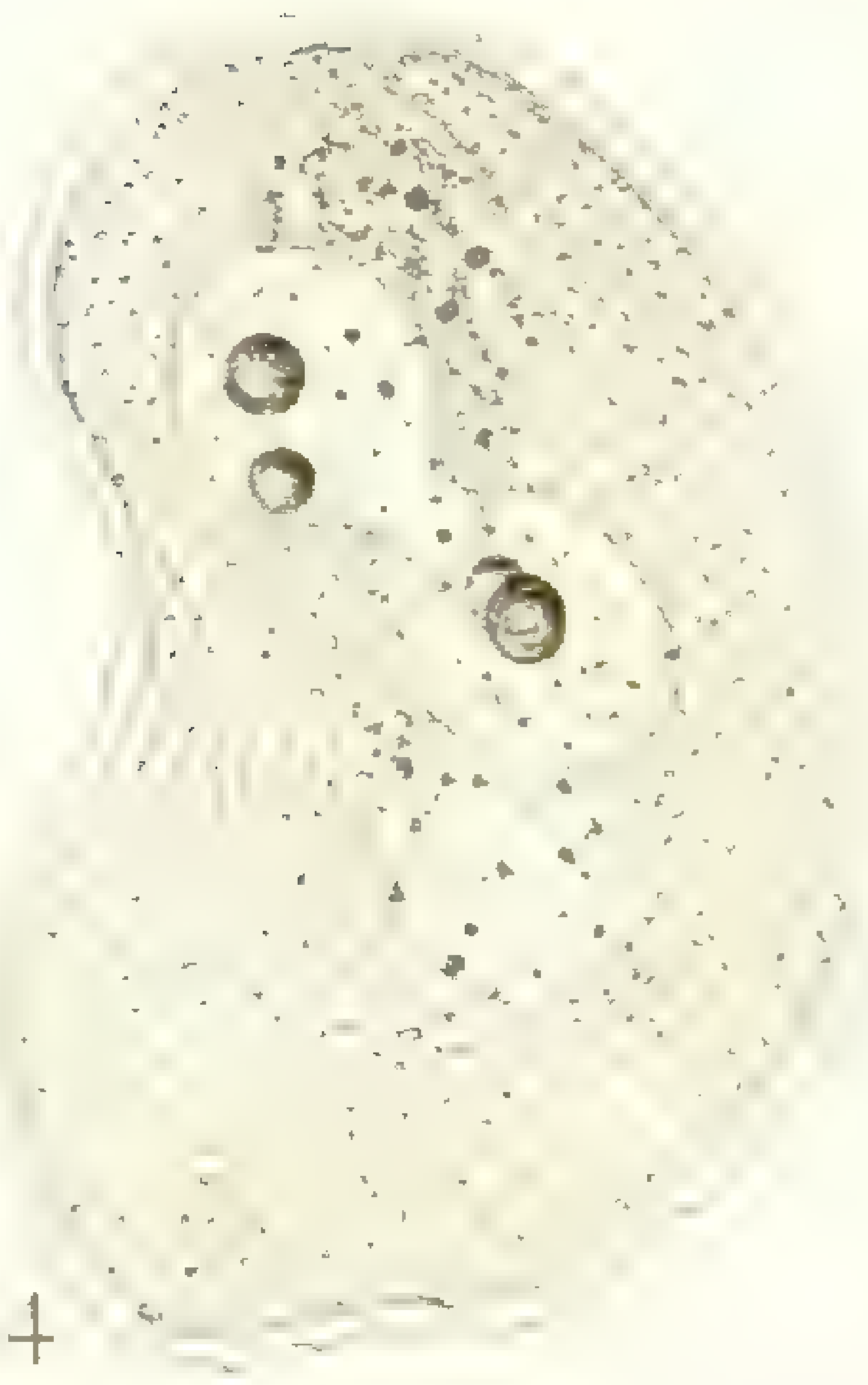

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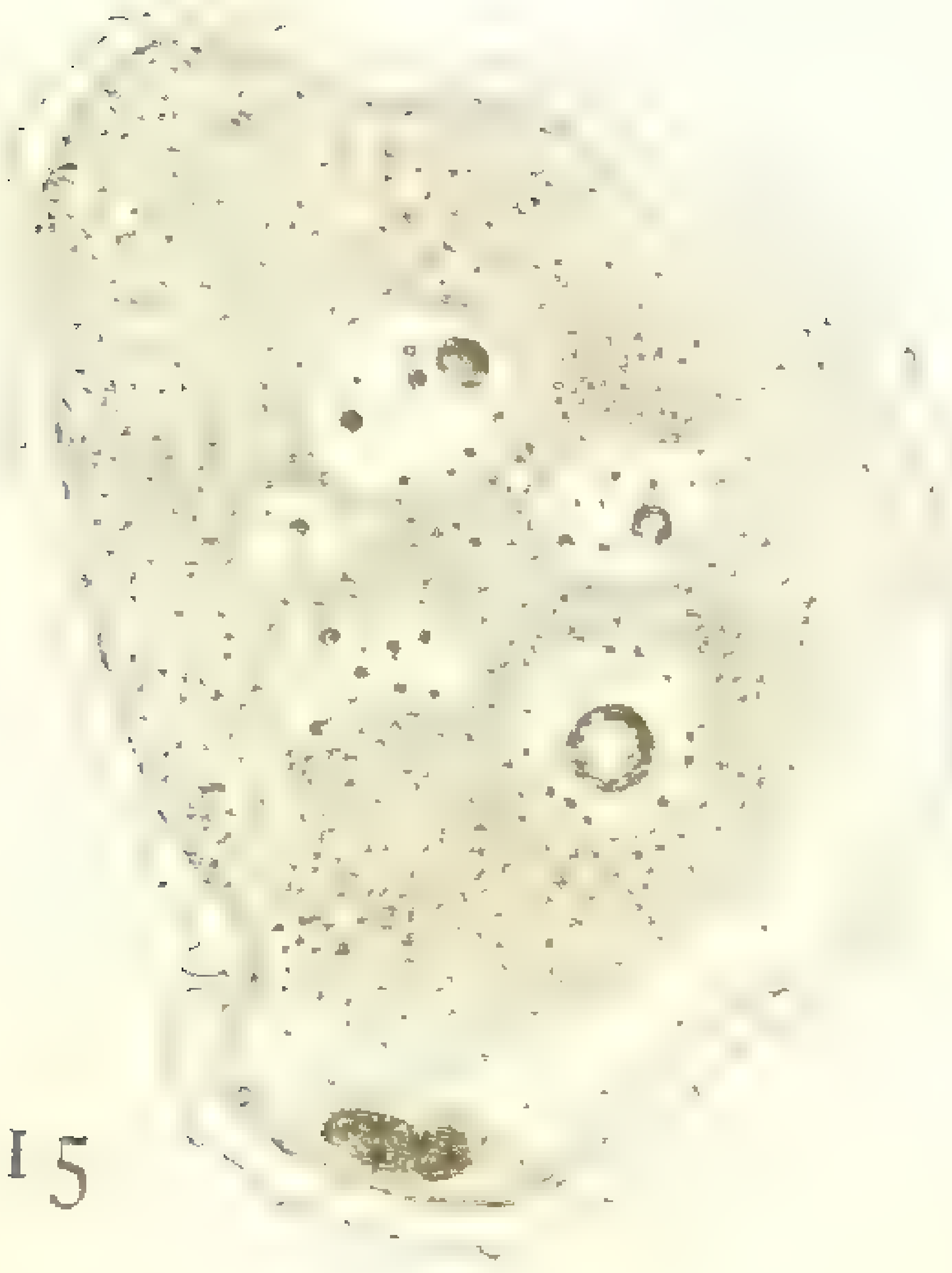

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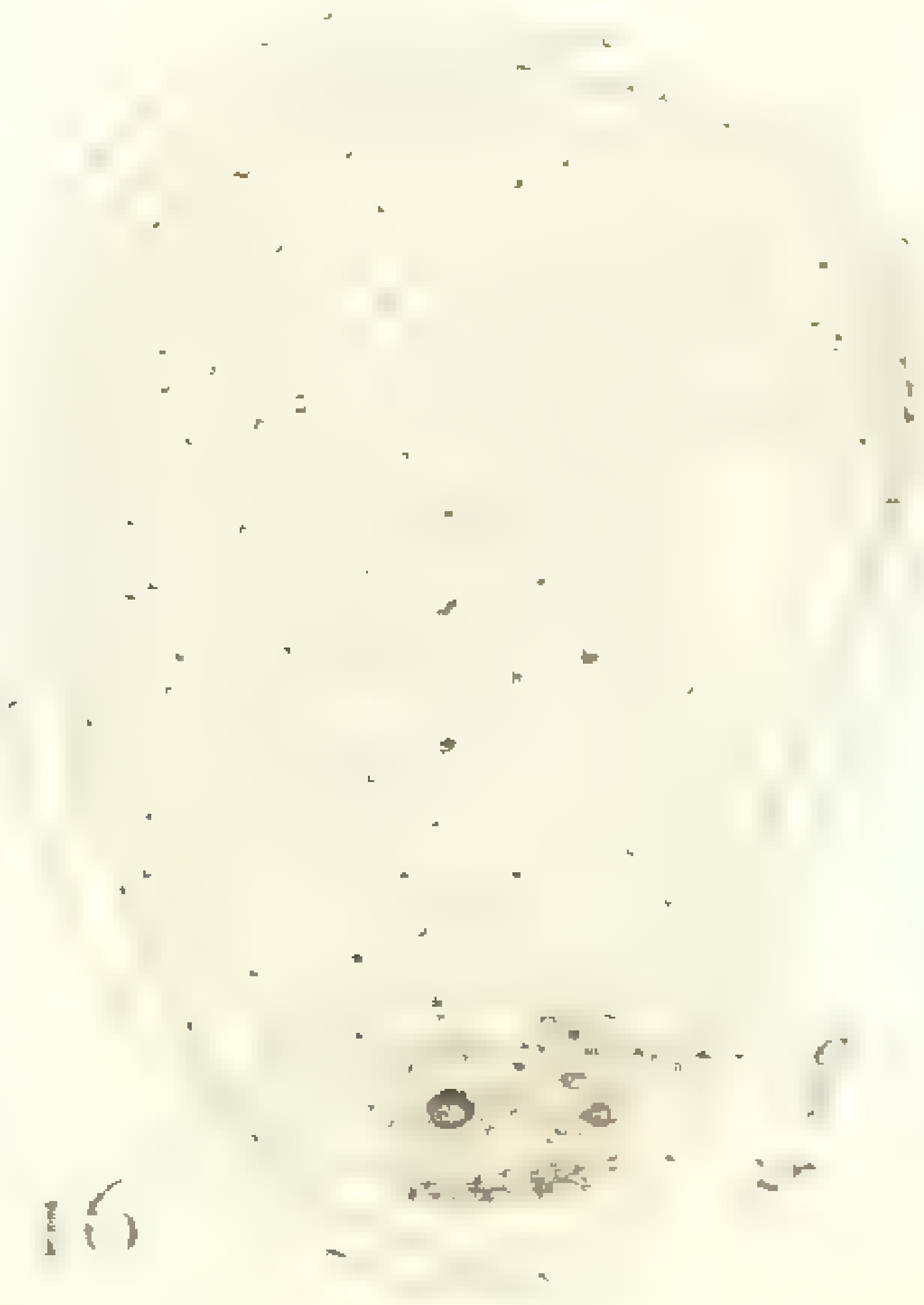

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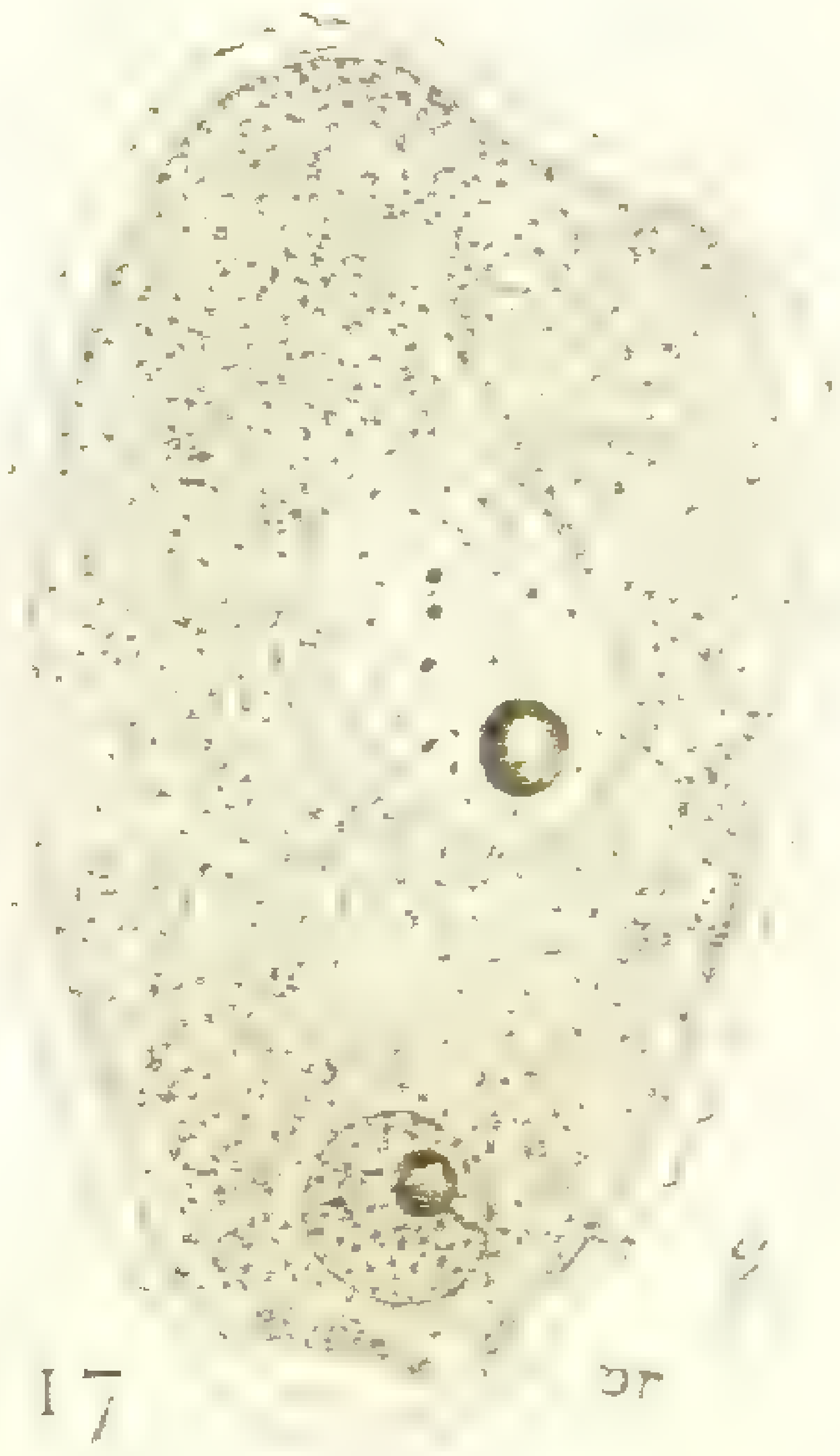

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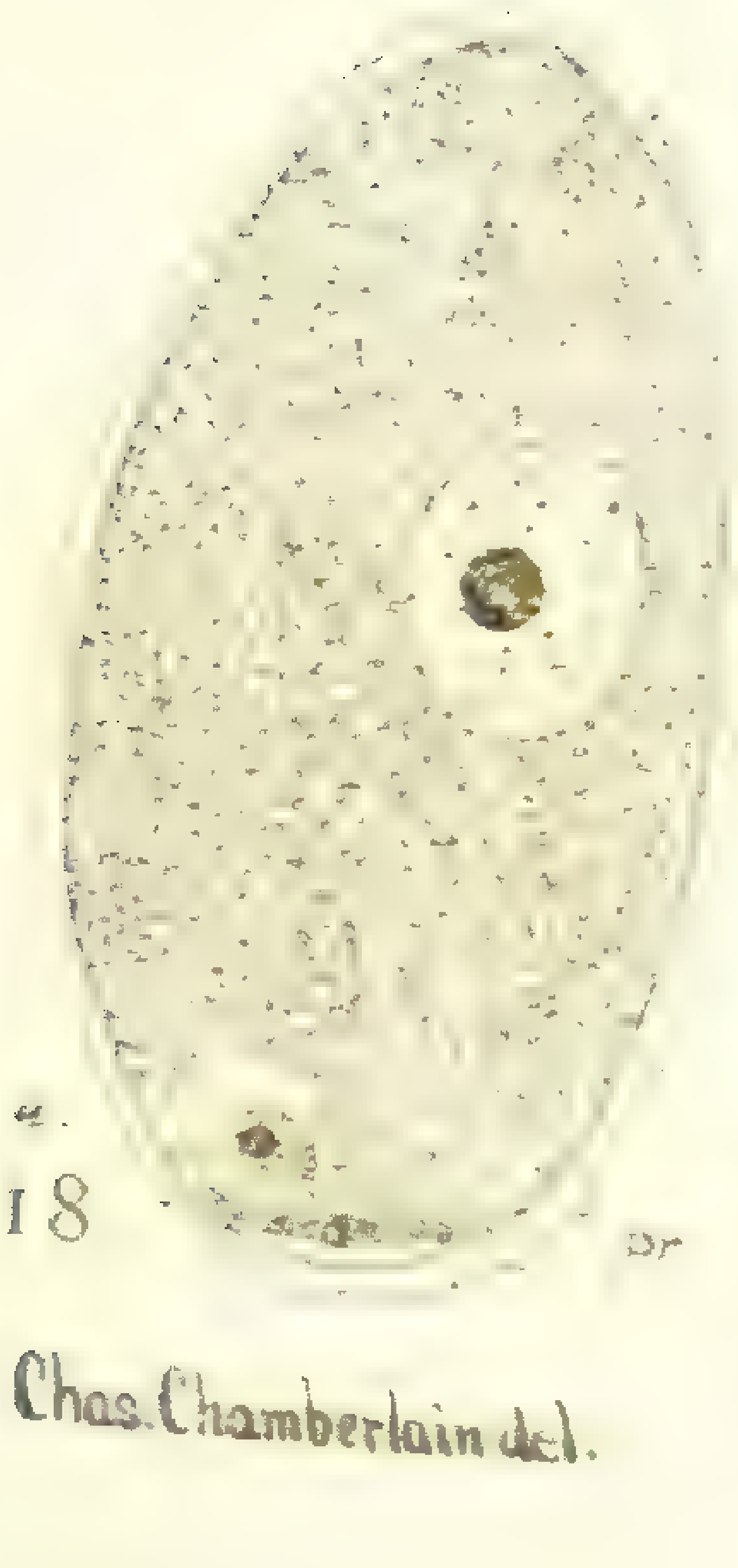

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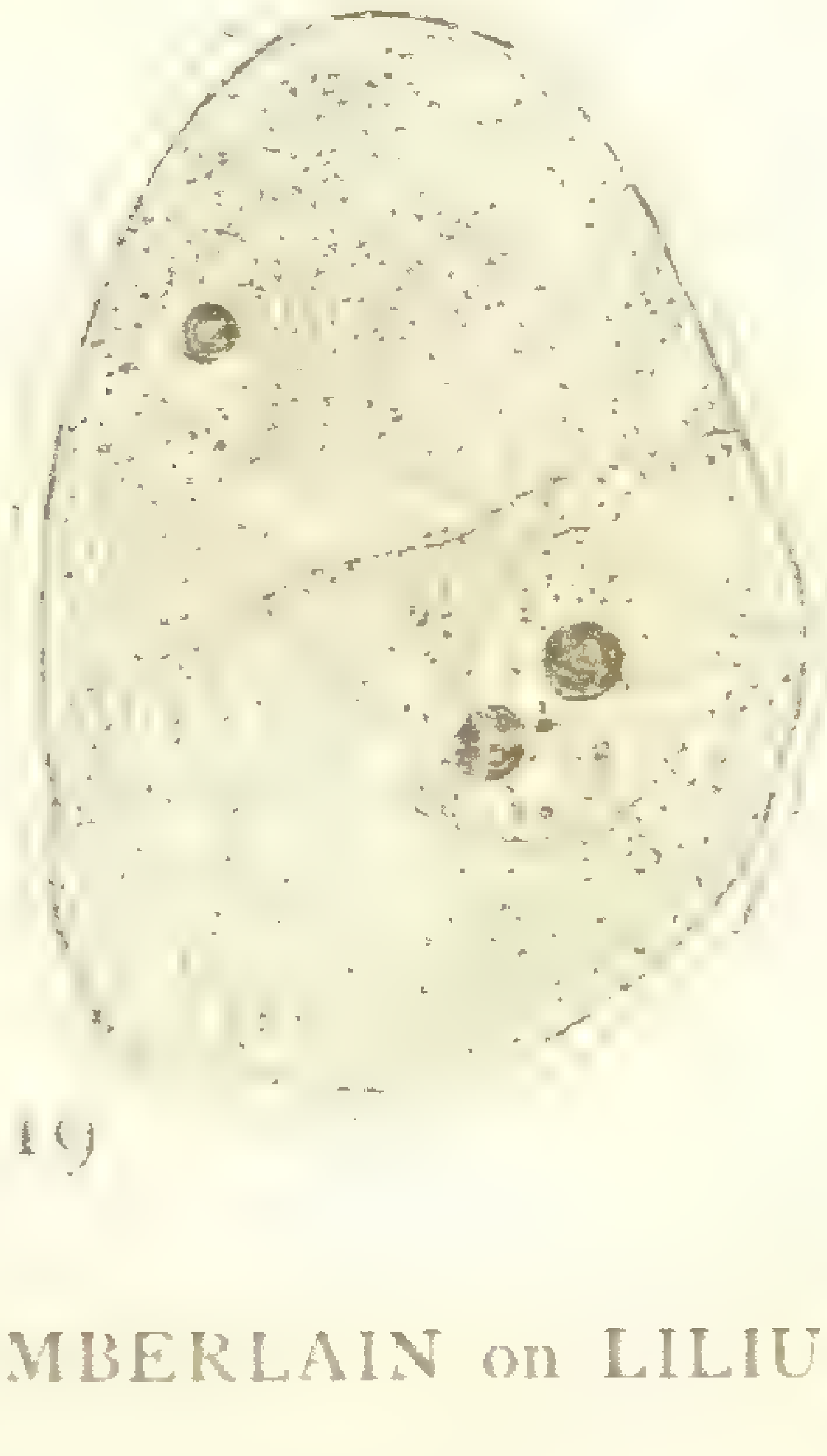

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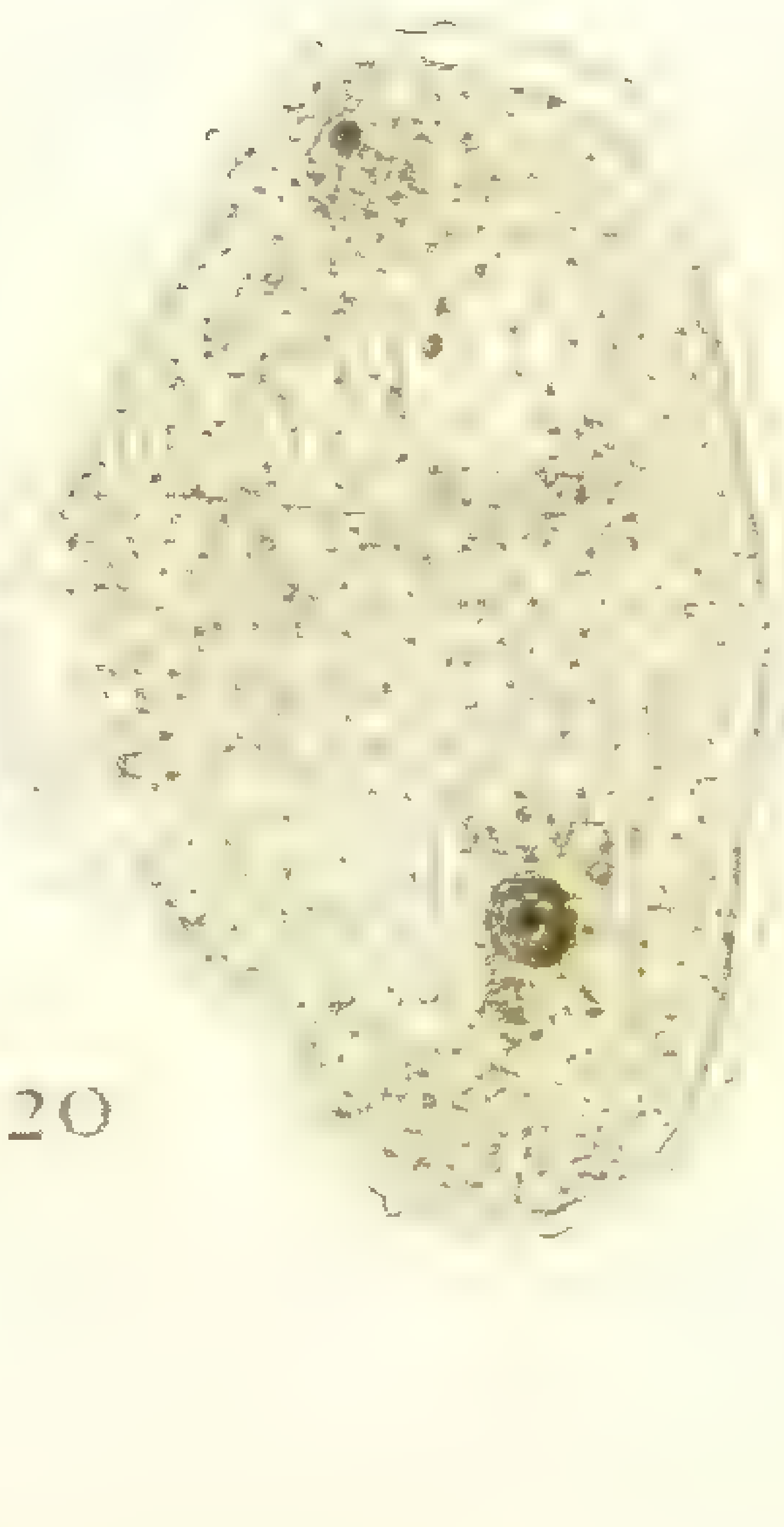

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Chas. Chamberlain del.

CHAMBERLAIN on LILIUM.

ACCOUNT OF INVESTIGATION.

In the young nucellus of *L. Philadelphicum* the archesporial cell soon shows its nature by a difference in size and staining reaction. As is well known, this cell in Lilium develops directly into the fertile macrospore, without cutting off a tapetal cell or dividing further into a number of macrospores. This gives an especially long period of growth for the development of the reduction nucleus. After the macrospore has attained some size its nucleus shows several large nucleoli, usually three in number, with the chromatin rather uniformly distributed and in close connection with the nucleoli. Whether the threads of the network really anastomose or not it would be difficult to determine, but such is the appearance. The threads contain numerous single chromatin granules which are arranged quite regularly, but are not all of the same size (*figs. 1, 1a*).

The chromatin network soon begins to thicken, and the granules grow larger, giving the nucleus a coarser appearance than in the earlier stages. The nucleoli at this stage usually have a homogeneous outer layer, while in the center is a large granular vacuole (*figs. 2, 2a, 3*). At the time when the integuments are just beginning to appear as minute projections on the side of the nucellus, the linin thread of the chromatin network becomes very thick and broad, and the chromatin granules undergo transverse divisions, making the whole network with double rows of chromatin granules instead of the former single row (*figs. 4, 4a*). At this stage, also, the whole chromatin band appears definitely to form a single continuous skein or spirem. At the same time, and even before, important changes are going on in the nucleoli. Sometimes these are of enormous size, with a great granular vacuole in the center. The nucleolus shown in *fig. 5* is larger than the average nucleus of the ovary tissue. In one case (*fig. 6*) such a nucleolus was found with a deep dent on one side. Whether or not this was caused by mechanical injury during preparation it is, of course, impossible to tell. The dent in this nucleolus may be of the same nature as the distortions which produce the so called "sickle stage," but here the nucleolus was not in contact with the nuclear membrane, but was lying free in the nucleus. The "sickle stage," was seen only in poor preparations, and hence I am inclined to regard it as an artificial product. In many nucleoli at the same stage there are a number of smaller vacuoles, instead of a large central one (*fig. 7*). There is no doubt but that the term vacuole is a misnomer, but for lack of a better one this name will be used for the larger clearer areas in the nucleolus.

After the division of the chromatin granules the entire chromatin band or spirem undergoes longitudinal splitting, producing a double linin thread, each thread containing a single row of chromatin granules (*figs. 8–9a*). The double number of chromatin bands makes a very characteristic appearance when compared with the earlier stages before splitting. There does not appear to be any substance connecting the two chromatin bands, the longitudinal fission appearing complete.

At this stage there often appear peculiar radiations or tangential filaments in the cytoplasm. These generally stretch from one side of the cell to the other, passing the nucleus as tangents (*fig. 8*). Whether this appearance was an artificial production or not I could not determine, but it is probable that it is a natural condition, as the threads appeared in numerous sections which did not seem to be otherwise disturbed. At this stage the two centrospheres, which were sometimes seen, still lie close together beside the nucleus.

After the splitting of the chromatin band the two resulting bands now begin to twist on one another, the twisted spirem being in marked contrast with the former parallel arrangement (*figs. 10, 10a*). In the meantime the nucleus has enlarged considerably. After the two threads have twisted quite closely together the resulting twisted chromatin band arranges itself so as to form twelve loops, the heads of the loops being close to the nuclear membrane. Each loop contains from one to three twists. At first the double nature of the chromatin band is still very evident (*figs. 11-11b*), but later the two linin threads are much more intimately associated, almost giving the appearance of a single ribbon with an irregular double row of chromatin granules (*figs. 11, 13*). At some point in this stage the so-called "synapsis" is said to occur. The chromatin loops now break apart and lie free in the nuclear area, while at the same time the nuclear membrane has almost entirely disappeared. Wherever the chromosomes were counted they were twelve in number. Thus it will be seen that the spirem first undergoes complete longitudinal fission and then breaks up into half the number of loops or chromosomes that are present in the cells of the sporophyte. The important feature in this pseudo-reduction of the number of chromosomes in the nucleus is not so much the fact that the spirem is cut into twelve parts as that it twists into twelve loops which predetermine the twelve divisions and the twelve chromosomes. The chromatin loops or chromosomes are not all of the same size. Indeed, there is often considerable difference in the lengths of the several chromosomes. In this way there may be considerable diversity in the subsequent reduction of the chromatin granules. Each chromosome then represents a double twisted chain of chromatin granules, and this double thread twisted on itself, so as to make one end of the chromosome a closed loop and the other with two limbs more or less free.

In the meantime the nucleolus becomes filled with a large number of small vacuolate bodies. Each of these bodies has a dark outer part with a light refractive center. Small bodies exactly like those within the nucleolus appear in the nucleus, and as soon as the nuclear membrane has disappeared some of these are also seen in the surrounding cytoplasm (*figs. 14, 15*). The formation of these micronucleoli occurs as follows: The nucleolus sends out a papilla-like projection, into which one of the vacuolate bodies enters and is then separated from the nucleolus by abstriction (*figs. 16-20*). The micronucleoli are thus all separated from the mother nucleolus by a process of budding. Just about the time when the individual chromosomes are formed and the nuclear membrane disappears, cytoplasmic radiations appear all around the nucleus. These threads pass out at right angles from the nuclear surface and extend to the walls of the cell. They appear like ordinary cytoplasmic radiations with numerous microsomes (*fig. 15*). Whether these threads are the same as the longitudinal threads of earlier stages I did not determine. However this may be, there is no indication of such crossing threads at this stage. If they were present they should have appeared as well as the divergent ones. It may be that the function of these radiations is to carry the micronucleoli out into the cytoplasm. The micronucleoli are perfectly differentiated by various stains. With anilin-safranin and gentian-violet they have a brilliant red appearance, which makes them stand out more prominently in the sections than they do in the figures. With cyanin and erythrosin the nucleoli are blue, while the surrounding cytoplasm and nucleus are red. They are also differentiated by other stains. The mother nucleoli continue to become smaller, and sometimes some of the chromosomes are collected around the nucleoli in such a manner as to suggest that the nucleoli have something to do with the growth of the chromosomes (*figs. 22a, 23a*). This, however, is doubtless merely an appearance, since twelve chromosomes have not much opportunity to avoid contact with two nucleoli in so small a space. Usually the greater number of chromosomes in a nucleus do not lie in the proximity of the nucleoli at all (*figs. 21-23*). By the time the chromosomes are ready to be arranged at the equator into the mother star the original nucleoli have entirely disappeared, the small daughter nucleoli or micronucleoli being scattered through the surrounding cytoplasm (*figs. 24, 25*). The micronucleoli show a tendency to become placed near the periphery of the cell and away from the nuclear spindle. However, they are often seen quite close to the poles and on the spindle, where with improper staining they might be confounded with the centrospheres. With proper staining, however, there is no possibility of such confusion, for the nucleoli in the cytoplasm have an entirely different structural appearance from the centrospheres, and also show a different staining reaction. There is no doubt in my mind that the micronucleoli lying on the spindle have often been mistaken for centrosomes, which would explain the instances where many centrospheres have been reported at the ends of the spindle threads; for it is just at this stage that the micronucleoli would have such a position.

The formation of the spindle was not traced. In the mother star stage one centrosome appears very definitely at each pole (*fig. 26*). During metakinesis the centrosome divides into two (*fig. 36a*). In the daughter skein stage two large centrospheres are sometimes seen at the poles (*fig. 38*). No special effort was made to bring out the centrospheres, and they were not often seen, but wherever they appeared they showed their normal structure and position.

During the formation of the chromosomes from the chromatin band the twisted loops begin to shorten and thicken, giving the appearance of a single twisted linin thread with an irregular double row of chromatin granules. The linin thread also, especially at this stage, stains a very dark purple or black with Delafield's haematoxylin, exactly like the chromatin granules themselves. At this stage also there is a deposit formed around the chromatin loop which gradually becomes thicker as the chromosome reaches maturity (*figs. 21–23 b*). With Delafield's haematoxylin and erythrosin this deposit stains a light pinkish red, while the chromatin band stains a very dark purple. At a later stage, just before the formation of the mother star, the whole chromosome begins to stain deeper, until it finally has a homogeneous appearance when treated with this double stain, and shows no structure whatever, the whole chromosome appearing like a huge mass of chromatin matter (*figs. 24–27*), and it is necessary to employ other stains to differentiate the chromatin band.

When the chromosomes become arranged on the spindle threads in the equatorial plane they are so situated that the end having the two free ends of the chromatin band are attached to the spindle threads, the loop being turned outward and projecting freely beyond the spindle (*figs. 27–28*). There is no doubt in my mind that this is the case, although it is difficult to determine, but there is a bare possibility that the chromosomes may be turned the other way. However, their position in the nuclear area, and their appearance and behavior on the spindle, indicate that the loops are turned outward. At this stage also the chromosome is generally stained so dark that no trace of the chromatin band is discernible, but in sections stained with anilin safranin, and gentian violet the central part stains darker and clearly indicates the position of the chromatin band (*fig. 30*). The splitting of the chromosome is gradual (*figs. 29–32*), and consists in the separation or untwisting of the chromatin coil, which is gradually pulled out until it lies like a straight band or rope on the spindle threads (*figs. 33–36*). The untwisting of the chromosome can be seen easily in all stages, and by proper focusing the entire coil can be traced. *Figs. 33–35*, which represent the later phases of this process, do not represent the coiled appearance as well as the sections. After the chromatin coils have straightened, the splitting takes place in the middle of each one at the equator. Thus there is an actual transverse division of the chromosomes, the half of each original chromatin loop passing to opposite poles of the spindle. Each daughter nucleus, therefore, receives about as many chromatin granules as there were in the mother nucleus, and although there is no diminution in the number of chromatin granules, only half of the granules originally present in the mother nucleus are represented in each daughter nucleus. It will be seen that although the chromosomes are not all of the same size and length, yet if the chromatin band breaks at practically the middle point each daughter nucleus receives about the same number of chromatin granules; and since the chromatin granules are the same in number as in the mother nucleus it cannot be proper to speak of a reduction in the amount of chromatin, although only half of the original chromatin granules are represented. There is no reduction in number but a reduction of one-half in kind. Whether there is a reduction in the number of chromatin granules before the egg nucleus is formed must be determined by studying the subsequent divisions. If there is no such subsequent reduction of granules then it would logically follow that the granules must fuse during the union of the sex nuclei. Otherwise the new sporophyte would contain twice the number of chromatin granules that the old one did.

This splitting of the chromosome first longitudinally and then tranversely, it will be seen, really amounts to the same thing as though the original chromosome were divided into four parts, and corresponds to the so-called "tetrad" stage reported by the zoologists. The word tetrad, however, could not properly be applied here, since a true tetrad does not appear.

After the chromosomes have collected about the poles of the spindle and are beginning to form the daughter skeins, cytoplasmic radiations, similar to those seen around the mother nucleus at the time when the micronucleoli were carried out into the cytoplasm, appear, and the micronucleoli often seem to be attached to them (*fig. 37*). Whether these radiations are organized from the centrosomes at the poles, as might seem possible from *fig. 38*, or are the same as those which surrounded the mother nucleus during the migration of the micronucleoli into the cytoplasm, I could not determine. It might be that they remain constantly in the cytoplasm during metakinesis, and only separated somewhat into two parts. As the daughter nuclei become more complete, the micronucleoli collect around them and begin to enter into the nuclei (*figs. 39, 40*). As they enter the nuclei and fewer are left in the surrounding cytoplasm, the cytoplasmic radiations become less distinct, and they finally disappear altogether when the nucleoli have all entered the daughter nuclei (*figs. 40–43*). The micronucleoli as they enter into the nuclei build up new daughter nucleoli by a continuous process of aggregation and fusion (*figs. 40–43*).

During the divisions of the two daughter nuclei which produce the four-celled embryo sac, the nucleoli act in exactly the same way as has been described for the first division, and the same kind of cytoplasmic radiations arise (*figs. 44–46*). In the divisions which complete the embryo sac, the same process was observed to occur; so it can be stated without exception that this action of the nucleoli in being thrown out into the cytoplasm and collected again into the daughter nuclei is the normal process for the whole gametophyte generation of *L. Philadelphicum*. Whether this process will be found to occur in the gametophyte generation of all angiosperms, or in all plant cells, is yet to be determined. There is often a marked peripheral placing of the nucleoli in the daughter nuclei which becomes very striking in certain cases where the nuclei lie in just the proper position (*fig. 47*). This would in itself be quite suggestive of the way in which the nucleoli were formed, even if they were not seen to enter from the outside.

The micronucleoli are constantly present in the cytoplasm from the time they leave the nucleus until they enter again. Of course it may be urged that the original micronucleoli are dissolved in the cytoplasm and new ones formed. If this is the case the dissolution of old ones and the formation of new ones must go on simultaneously. It is not intended to contend here that the nucleolus is a permanent cell organ, for more observation is needed for such a generalization. But that the nucleoli pass out and enter again to form new ones in the daughter nuclei cannot be denied. The strongest argument in favor of regarding the nucleolus as a definite body or organ seems to the writer to be the fact that in many plants and tissues the number is constant. Thus in many cases the number in each nucleus is almost absolutely constant. Are such examples of constancy at hand for other excretions or food products? That the number is often variable is no argument against its fundamental character. The number of nuclei in many cells is also exceedingly variable.

During the divisions of the nuclei in the embryo sac the spindle threads undergo a thickening in the middle as though a nuclear plate and cell-wall were to be formed (*figs. 38–41*), and the spindle often persists from one division to another, so that four daughter nuclei may appear to be connected by three spindles (*figs. 45, 46*). This thickening of the spindle threads would seem to be an inheritance from a true thallus with regular cell walls.

GENERAL DISCUSSION.

Chromosomes.—It has been claimed by botanists, especially Guignard and Strasburger, that during the karyokinetic division of the reduction nucleus in plants the chromosomes undergo longitudinal division just as in ordinary vegetative cells. This has also been maintained by Boveri, Hertwig, and Brauer in regard to Ascaris, where the so-called "tetrad" is said to arise by a double longitudinal splitting of the primary chromatin rod. Recently, however, it has been found by Rückert, Häcker, and vom Rath, that in certain arthropods each "tetrad" arises by one longitudinal and one transverse division of the primary chromosome. This would make a true reduction in Weismann's sense.

Since writing the present investigation the author has read a paper by Calkins[1] in which the formation of "tetrad" chromosomes is described as occurring in the spore mother cells of two ferns, *Pteris tremula* and *Adiantum cuneatum*. The author is quite certain that transverse division occurs in these chromosomes, although he could not tell whether the reduction took place in the first division or in the division following. He thinks, however, that the first division is longitudinal and the second one transverse, so that the reduction would take place in the second division. This, however, is merely an inference, and he seems to have no direct evidence as to when the transverse division takes place, if it occurs at all. Although the work is a very commendable one the author's substitution of zoological for botanical terms seems unwise, since it is still doubtful whether the zoologists have arrived at the exact truth in every case or not. The term "tetrad" in connection with the chromosomes is especially objectionable in botany, since "tetrad" had a definite meaning many years before chromosome "tetrads" were thought of. A different term seems advisable in order to avoid the confusion which must arise if it should be introduced into botany.

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[1] Chromatin reduction and tetrad-formation in pteridophytes. Bull. Torr. Bot. Club **24**: 101–115. 1897.

Mottier[2] has also reported a transverse division of the chromosomes in the pollen mother cells of Lilium. He reports that the pseudo-reduction takes place in the first division and the transverse splitting of the chromosomes in the second. However, his evidence is not very conclusive, and his figures are rather indefinite, so that it is not possible to judge whether his conclusions are justifiable or not. In the case of the reduction nucleus of the embryo sac of *L. Philadelphicum* the divisions which form the macrospores are skipped, so I am not able to generalize or predict what would occur in the normal process where a number of macrospores or microspores are formed.

If we accept Dixon's evidence, it seems probable that the reduction takes place in the first division of the pollen mother cells. In the pollen mother cells of *L. longiflorum*, Dixon[3] found that during the first division the chromosomes sometimes formed a loop which he thinks may be derived possibly from a loop in the original chromatin band, and sometimes they are twisted round each other. He says that while they lie in the equator the two parts of the chromosome are in close contact and seem fused together at their inner extremities, and that during metakinesis the two rod-like portions part from one another. He says: "From the process described it appears probable that each chromosome in this karyokinesis represents two of the previous nuclear divisions which have become more or less completely united end to end." "Thus the reduction in number is effected by an end to end fusion of the chromosomes as Strasburger has already suggested." "The next division by which the pollen tetrads are formed takes place probably according to the normal karyokinesis in plant-cells."

It must be borne in mind, however, that there is at present no possible way of telling in such forms as Lilium what becomes of the individual chromosomes which go to make up the spirem of the reduction nucleus. The spirem is a continuous thread before it breaks up, and to say that each piece represents two of the former chromosomes is a mere assumption dangerous to make. It is just as probable, so far as we know, that the breaking may take place anywhere, and that the individuality of the former chromosomes is entirely lost.

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[2] Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen einiger Dikotylen und Monokotylen. Jahrb. f. wiss. Bot. **30**: 169-204. 1897.

[3] The nuclei of Lilium longiflorum. Ann. Bot. **9**: 663-665. 1895.

Turning now to Guignard's [4] figures of the division of the pollen mother cells and embryo sac nucleus of *L. Martagon*, we find a wonderful agreement in his figures with my own. If the chromosomes represented in Guignard's *figs. 48* and *49* had the chromatin band closed into a loop they would agree exactly with mine from this stage on. His figures indicate that the process of splitting was the same as I have determined, but that he was misled by thinking that his double chromatin band was open at both ends. And were no conflicting evidence at hand I should say that his figures of the divisions in the pollen mother cells establish a transverse splitting of the chromosomes for the first division of the pollen mother cells and not for the second. Whatever the fact may be, it is to be hoped that evidence on this point will soon be offered which will relieve the present uncertainty.

It will be seen, as already stated, that in *L. Philadelphicum*, because of longitudinal splitting of the spirem and its subsequent transverse division during metakinesis, we have to do with exactly similar phenomena as those which have been described for "tetrad" formation, although the chromosome never gives any appearance of a separation into four distinct parts, but as has been described forms a double twisted coil. The early longitudinal division of the spirem, before it breaks up into the reduced number of chromosomes, has also been found by vom Rath [5] in the insect *Gryllotalpa vulgaris*.

[4] Nouvelles Études, etc. Ann. Sci. Nat. Bot. VII. **14**: 163–296. 1891.

[5] Zur Kenntniss der Spermatogenese von Gryllotalpa vulgaris. Arch. f. Mik. Anat. **40**: —. 1892.

Miss Sargent[6] has recently studied the division of the reduction nucleus of *L. Martagon*, but was unable to detect any transverse division of the chromosome, although some facts observed by her point that way. She has much to say in regard to synapsis, but I am fully convinced that many of the appearances she describes were due to poor treatment of the material. In fact, I regard the so-called stage of synapsis as simply a product of poor preparation. In none of my better preparations have I found such an appearance, in fact it was so rare in the stages where it is reported to occur that I should have missed it altogether had I not made a careful search for its appearance, although I had a large number of my own preparations and had the privilege of looking over a large number put up by others in the laboratory. In the stage when the contraction usually occurs the chromatin band is quite free within the nuclear membrane, since it is at this time twisting and orienting itself to form the twelve chromatin loops. Everything therefore is favorable for an artificial contraction. When the contraction does take place it is often exactly in the middle of the nuclear area, and sometimes it occurs in such a manner that the large nucleolus is left entirely free in the nuclear area away from the mass of chromatin. Miss Sargent's explanation, therefore, that the chromatin contracts around the nucleolus in order to keep this "washy" looking body from escaping beyond the confines of the chromatin because of its supposed dissolution at this period, I venture to regard as erroneous. In various other plants I have seen contractions of this sort, but always in very poor preparations, from which it would not be wise to draw conclusions, and I believe that I am safe in saying that the nucleolus is much more often free in the nuclear area than caught in the contracted meshes of the spirem.

Although a transverse division of the chromosome, or a true reducing division, is here established for the macrospore of *L. Philadelphicum*, the writer does not wish to be understood as thinking that this will give any support to Weismann's theory of heredity. It has been shown already by certain botanists that this theory breaks down entirely in the case of plants. Whether Strasburger's theory of reduction is correct or not the future must decide. We are evidently not yet ready to establish a theory of reduction, as we are dealing with phenomena concerning which hardly two observers agree.

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[6] The formation of the sexual nuclei in Lilium Martagon. I. Oogenesis. Ann. Bot. 10: 445–477. 1896.

Nucleoli.—Apparently no structure in the cell is so little known as the nucleolus, and one needs only examine the literature of the subject to discover how little has been done that can stand the test of criticism. One of the most common ideas in regard to this body was that it represents a globule of food material which can be used by the nucleus or cell in general as occasion demands. Strasburger,[7] in 1895, suggested that the substance of the nucleoli serves for the construction of the spindle threads, but it is doubtful whether there ever was any very strong evidence in favor of such a view. Went,[8] in 1887, saw in the endosperm nuclei that the nucleoli were lying in contact with the chromatin threads, and he thought the substance of the nucleoli was taken up by the chromosomes. It is very doubtful, however, whether any part of the nucleoli ever goes to aid in the formation of the chromosomes. Tangl[9] was the first to observe the extrusion of the nucleolus into the cytoplasm. This was seen in the pollen mother cells of *Hemerocallis fulva*. Karsten[10] attempted to show that the centrosomes had their origin in extruded nucleoli. It was soon shown by Guignard and others, however, that this was not the case, and that Karsten did not see true centrosomes at all. Belajeff[11] has the nucleoli passing out into the cytoplasm, but he claims that they are dissolved and that new ones arise in the daughter nuclei.

[7] Karyokinetische Probleme. Jahrb. f. wiss. Bot. **28**: 151–204. 1895.

[8] Beobachtungen über Kern- und Zelltheilung. Ber. d. d. bot. Ges. **5**: 247. 1887.

[9] Die Kern- und Zelltheilung bei der Bildung des Pollens von *Hemerocallis fulva* L. Denkschr. d. Kais. Akad. d. Wiss. zu Wien. **45**: 65. 1882.

[10] Ueber Beziehungen der Nucleolen zu den Centrosomen bei *Psilotum triquetrum*. Ber. d. d. bot. Ges. **11**: 555–562. 1893.

[11] Zur Kenntniss der Karyokinese bei den Pflanzen. Flora —: 436. 1894.

A. Zimmermann[12] found that at the beginning of nuclear division the nucleoli pass out of the nucleus into the cytoplasm, and that later in the metaphase of the division they are again taken up into the daughter nucleus. He advances the proposition "omnis nucleolus e nucleolo." This process was observed in the pollen mother cells of *Lilium Martagon*, where the nucleoli are said to break up into numerous small granules. Zimmermann also observed the extrusion of the nucleoli into the cytoplasm in *Hyacinthus candicans*, *Fritillaria imperialis*, *Equisetum*, and *Psilotum*. The extrusion was also found in the primary embryo sac nucleus of *Lilium Martagon* and *Fritillaria imperialis*, in the vegetative cells of the root tips of *Vicia faba*, and in the stem tips of *Phaseolus communis* and *Psilotum triquetrum*. Rosen[13] has also found nucleoli in the cytoplasm of the cells of roots of Hyacinthus. Zimmermann's observations were immediately disputed by Guignard, Humphrey, and Strasburger. Humphrey[14] considers that the phenomena recorded by Zimmerman are the results of manipulation.

Zimmermann believes that the nucleoli which are thrust out into the cytoplasm return again into the daughter nuclei. In his last work[15] he still thinks that this occurs in some cases, but that it may not be universal. He considers that there is a fusion of the nuclei even in the cytoplasm, and I have also found that this seems to be the case, although generally no fusion of micronucleoli occurs until they have entered the daughter nucleoli. Whether the nucleoli are real organs of the cell of course still remains an open question, but for the divisions that take place in the embryo sac of *Lilium Philadelphicum*, my own study assures me that in the prophase of nuclear division the nucleoli give rise to a large number of micronucleoli which are carried out into the cytoplasm, and in the metaphase of the division they are again collected into the daughter nuclei, where by repeated fusions they form the large nucleoli of the mature daughter nuclei.

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[12] Ueber das Verhalten der Nukleolen während der Karyokinese. Beiträge zur Morphologie und Physiologie der Pflanzenzelle **2**: 1–35. 1893. Tübingen.

[13] Beiträge zur Kenntniss der Pflanzenzellen. Beitr. z. Biol. der Pflanzen (Cohn). **7**: 225–312. 1895. [Heft 2].

[14] Nucleolen und Centrosomen. Ber. d. d. bot. Ges. **12**: 108–117. 1894.

[15] Die Morphologie und Physiologie des pflanzlichen Zellkernes. Jena. 1896.

Cytoplasmic radiations and spindle threads.—The tangential threads which I observed in the early stages of the development of the macrospore nucleus are no doubt the same as those recently described by Mottier and others as being the beginnings of the achromatic spindle. They do not converge to definite points, however, but pass almost in straight lines across the cell from one wall to the other, the greater number appearing to pass in a direction longitudinal to the long axis of the growing macrospore. From their varying direction it follows that there must be numerous points of intersection, but it does not appear that any number intersect at a given point. At a later stage, in very fine sections, these radiations do not appear at all, but a new set of cytoplasmic threads appear diverging in every direction, and at right angles to the nuclear surface. These radiations are the same as those figured so beautifully by Guignard. Whether these diverging radiations represent the same structures as the earlier tangential threads or not I could not determine. They were never seen to converge to definite points, but I can easily imagine how in a contracted condition of the cytoplasm they might give such an appearance. My belief is that the real purpose of these radiations is to carry out the micronucleoli into the cytoplasm. They appear just when the micronucleoli begin to migrate, and it is difficult to imagine how the nucleoli could pass outward unless carried by streams of cytoplasm.

The formation of the spindle was not followed, but in the mother star stage the spindle is always bipolar and ends in a definite point. No appearance of a multipolar spindle was ever observed, unless in cases where the spindle had been cut or torn Even granting that the spindle is formed as Farmer states, there may still be two unseen centrospheres toward which all the small poles of the multipolar spindles are attracted. It is inconceivable to the writer how a definite bipolar spindle should always be formed from several minor poles which extend in every direction, without the control of some body or other influence at a definite point. The writer has preparations in which very definite centrospheres are to be seen at the poles of the mother star. These preparations have been examined by a large number of experienced observers at more than one laboratory, so that the sweeping assertion that no such bodies have ever been observed in the higher plants is certainly unwarranted.

In this connection it might also be proper to speak of the large spherical bodies figured by Farmer[16] on his multipolar spindles in the pollen mother cells of *Lilium Martagon*. There is no doubt in my mind, from the description and figures, that these were micronucleoli, and had nothing whatsoever to do with the spindle, especially as he speaks of granules which are colored by those stains which differentiate the chromatic elements of the nucleus.

It must be remembered that it is an impossibility to find the spindle converging to a single pole when the nucleus and spindle have been cut into half a dozen slices, and more often cut diagonally than longitudinally. No one denies that multipolar spindles are to be seen in such cases. But it will be remembered that most of these so-called multipolar spindles have been reported in just such cases, nearly always in connection with the enormous nuclei of the pollen mother cell or the reduction nucleus of the embryo sac. The cell and its contents would have to be made of steel or flint if it were to preserve its centrospheres and poles in proper position after having been cut into half a dozen or more sections. It is even claimed that in the thinnest sections it is easily seen that the spindle does not come to a pole, which is certainly not surprising.

The numerous radiations which appear around the daughter nuclei, if the suggestion is correct for those around the mother nucleus, are for the purpose of returning the micronucleoli into the daughter nuclei. As has been said, the micronucleoli are often seen on these radiations on their return, and the radiations disappear as soon as all the micronucleoli have entered the daughter nuclei, as if there remained no further function for them. There is no spindle to be formed with which they might be associated, as is the case with those around the mother nucleus.

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[16] On nuclear division in the pollen mother cells of *Lilium Martagon*. Ann. Bot. 7: 392–396. 1893.

That the central spindle threads are not necessary for the formation of the daughter nuclei is shown by the fact that the entire central spindle may persist in the cytoplasm for several divisions. At some future time the writer hopes to discuss the origin of the spindle threads and their relations to the centrosomes.

SUMMARY.

1. In *Lilium Philadelphicum* the archesporial cell develops directly into the macrospore, and its nucleus during the first-division appears with twelve chromosomes, or half the number which are present in the vegetative nuclei. At quite an early stage in the development of the macrospore the linin thread of the chromatin network begins to thicken, and the chromatin granules undergo transverse fission. After division of the chromatin granules the whole chromatin band undergoes longitudinal splitting, and the double threads thus produced begin to twist upon each other. This twisted band finally manifests itself as a single continuous spirem, which doubles up and twists into twelve loops. The twelve loops break apart and give rise to the twelve chromosomes. The two linin threads with their granules, which compose the loop, continually become more intimately associated, so that the loop appears like a single linin thread with two irregular rows of chromatin granules. The chromatin loops become shorter by contraction, and receive a thick deposit of some substance which stains light at first but later takes the same color as the chromatin, giving the chromosomes the appearance of homogeneous, somewhat irregularly bean shaped bodies, in which the original chromatin loop is rarely visible The chromosomes arrange themselves in

the equatorial plane in such a manner that the end containing the two free ends of the original chromatin loop is in contact with the spindle fibers. The fibers gradually pull the chromosomes apart in such a manner that the original chromatin loop is untwisted and finally cut in two by a transverse division. Thus the parts of each chromosome which pass to the daughter nuclei represent transverse halves of the original chromatin loop, formed from about one twelfth of the double spirem.

2. The nucleus at first usually has about three nucleoli, each with one or more large granular vacuoles. After the longitudinal splitting of the chromatin band there arise in the nuclei numerous small vacuolate bodies. These are successively abstricted from the mother nucleolus by a process of budding, and give rise to numerous micronucleoli, which all pass out into the cytoplasm before the formation of the mother star, and later, at about the beginning of the close daughter skeins, these micronucleoli all pass back into the daughter nuclei, and by aggregation form the new nucleoli of the daughter nuclei. This process is repeated for every division of the female gametophyte.

3. At about the time of the division of the chromatin granules, there appear in the cytoplasm peculiar cytoplasmic threads, which pass from one side of the cell to the other, and are mostly tangent to the nucleus. At a later stage, at about the beginning of the nucleolar migration, these threads have disappeared, and numerous radiating threads pass out at right angles from the nuclear surface and extend to the cell walls. These radiations seem to hold some relation to the migration of the micronucleoli. Similar radiations appear around the daughter nuclei, and the micronucleoli, as they are drawn into the daughter nuclei, seem to be in contact with these cytoplasmic threads.

4. Two centrospheres appear beside the resting nucleus, and in the mother star stage a single centrosphere appears at each pole of the spindle; while a little later, during metakinesis, a centrosphere appears at each point with a double centrosome.

In the daughter skein stage there are two centrospheres at each pole, which are often quite distinct and can easily be differentiated from the micronucleoli.

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EXPLANATION OF PLATES XXXVII–XXXIX.

All the figures are reduced to three-eighths of their original size. The magnification given with each figure is the original magnification of the drawings before reduction.

FIG. 1. Part of a young nucellus showing the archesporium developing directly into a fertile macrospore. Anilin-safranin, gentian-violet. × 1200.

FIG. 1*a*. A small part of the chromatin network showing a single row of chromatin granules on the linin threads. × 2250.

FIG. 2. Nucleus a little older than in *fig. 1*. The chromatin network seems to be in close connection with the nucleoli. Chromatin granules considerably larger. Anilin-safranin, gentian-violet. × 1200.

FIG. 2*a*. Linin thread with chromatin granules.

FIG. 3. Nucleolus; the usual appearance before the division of the chromatin granules. Delafield's haematoxylin, erythrosin. × 2250.

FIG. 4. Section of nucleus at the stage when the integuments are just beginning to appear. The linin thread is very thick and the chromatin granules are dividing transversely. There were four large nucleoli in this nucleus. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 4*a*. Small piece of the linin thread showing arrangement of the chromatin granules. × 2250.

FIG. 5. An enormous nucleolus, with large central vacuole, which has a granular structure. Just before division of the chromatin granules. Anilin-safranin, gentian-violet. × 2250.

FIG. 6. Nucleolus about the same stage as *fig. 5*, with a depression or dent on one side. Anilin-safranin, gentian-violet. × 2250.

FIG. 7. Nucleolus with several vacuoles; same stage as *figs. 6* and *7*. Anilin-safranin, gentian-violet. × 2250.

FIG. 8. Macrospore with nucleus containing double chromatin bands produced by longitudinal splitting. Two centrospheres on one side of the nucleus. The cytoplasm contains peculiar radiating strands. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 8*a*. Section of the same nucleus showing another nucleolus. × 1200.

FIG. 8*b*. Short piece of double chromatin band. × 2250.

FIG. 8*c*. Double chromatin band a little wider than *fig. 8b*. × 2250.

FIG. 9. Thin section of a macrospore with nucleus containing double rows of chromatin bands. The nucleolus shows a number of small vacuoles. Anilin-safranin, gentian-violet. × 1200.

FIG. 9*a*. A single thread of the double chromatin band showing the arrangement of the chromatin granules on the linin thread. × 2250.

FIG. 10. Nucleus in which the double threads of the chromatin band are beginning to twist on each other. Anilin-safranin. gentian-violet. × 1200.

FIG. 10*a*. A double twisted chromatin band crossed by a single one. The other part was very likely cut away. × 2250.

FIG. 11. Section of a nucleus in which the double twisted chromatin band has twisted into twelve loops with the heads toward the nuclear membrane. Anilin-safranin, gentian-violet. × 1200.

FIG. 11*a*. Adjoining section of the same nucleus. × 1200.

FIG. 11*b*. Two loops from *fig. 11*. × 2250.

FIG. 12. Chromatin loop a little later than *fig. 11*. The two linin threads have twisted more closely together, presenting more nearly the appearance of a single band. Anilin-safranin, gentian-violet. × 2250.

FIG. 13. Thin section of macrospore showing chromosomes immediately after the breaking up of the chromatin band into the twelve chromosomes. The nuclear membrane has almost disappeared. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 14. Section of macrospore showing the double nature of the chromatin loops, a large vacuolate nucleolus, and three micronucleoli, one of which has passed beyond the nuclear limits. Anilin-safranin, gentian-violet. × 1200.

FIG. 15. Section of macrospore showing fine cytoplasmic radiations extending outward from the nucleus. In the nuclear area is one large nucleolus and numerous micronucleoli. Some of the micronucleoli have traveled far out into the cytoplasm. Anilin-safranin, genatin-violet. × 1200.

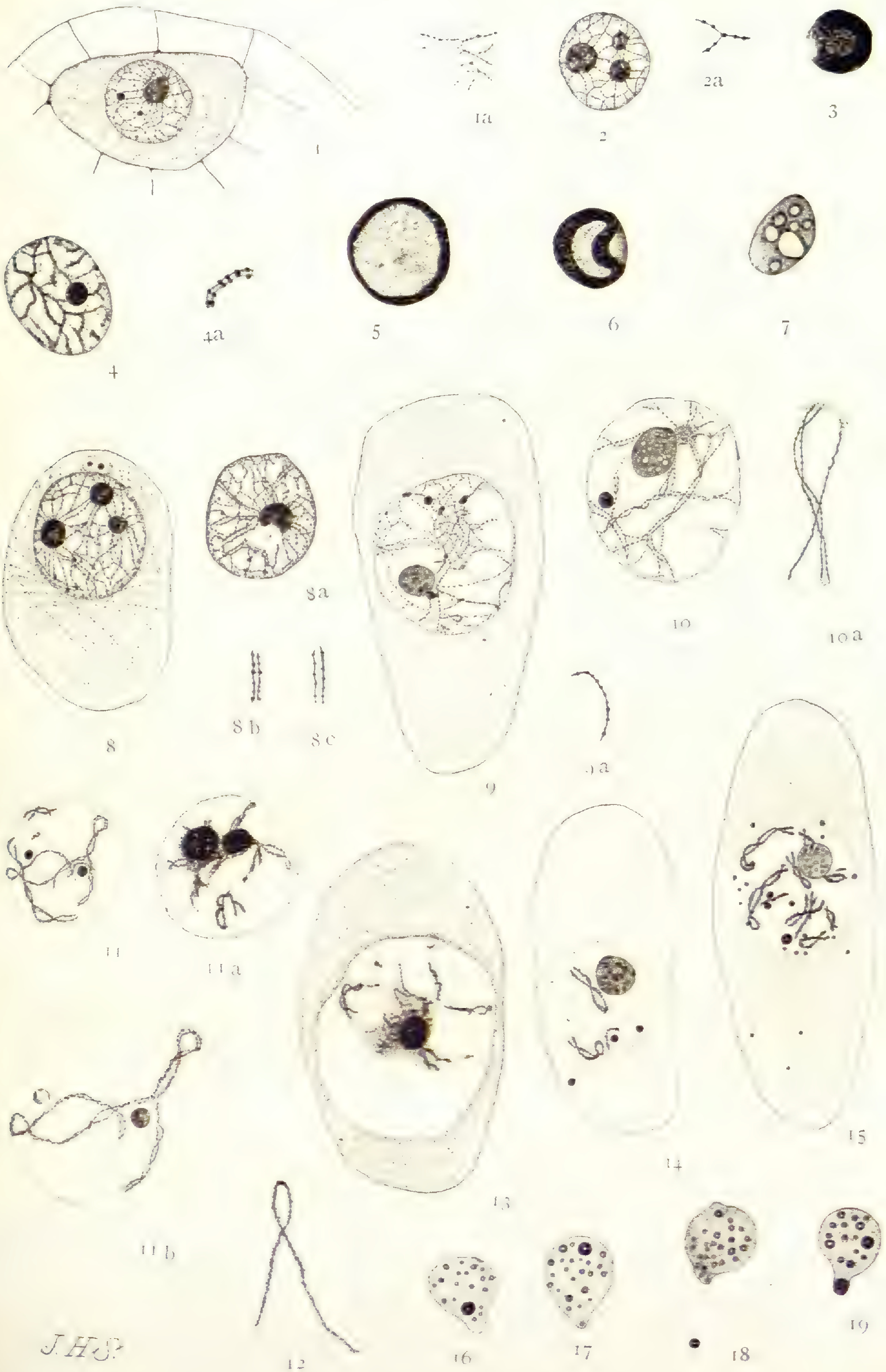
FIG. 16. Nucleolus with vacuolate bodies; just before the breaking up of the chromatin band. Anilin-safranin, gentian-violet. ×2250.

FIG. 17. Nucleolus with vacuolate bodies. Anilin-safranin, gentian-violet. × 2250.

FIG. 18. Nucleolus with small spherical vacuolate bodies. A small nucleolus lying outside of the nuclear boundary. Anilin-safranin, gentian-violet. × 2250.

FIG. 19. Nucleolus with one of the vacuolate bodies apparently being extruded. Anilin-safranin, gentian-violet. ×2250.

FIG. 20. Outline of a nucleus, showing one large vacuolate nucleolus and a micronucleolus within the nuclear area, a small vacuolate nucleolus outside. Anilin-safranin, gentian-violet. × 2250.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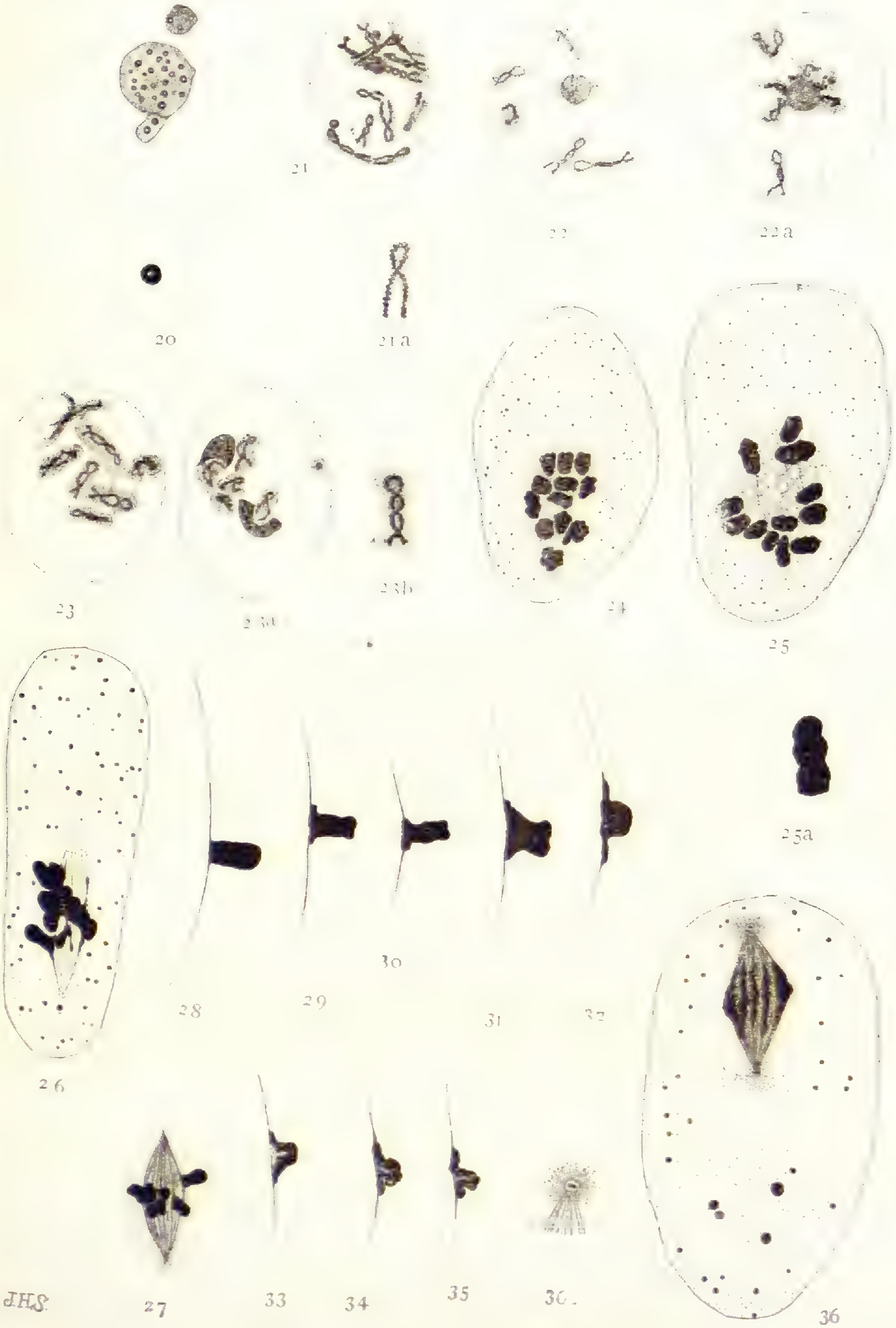
SCHAFFNER on LILIUM.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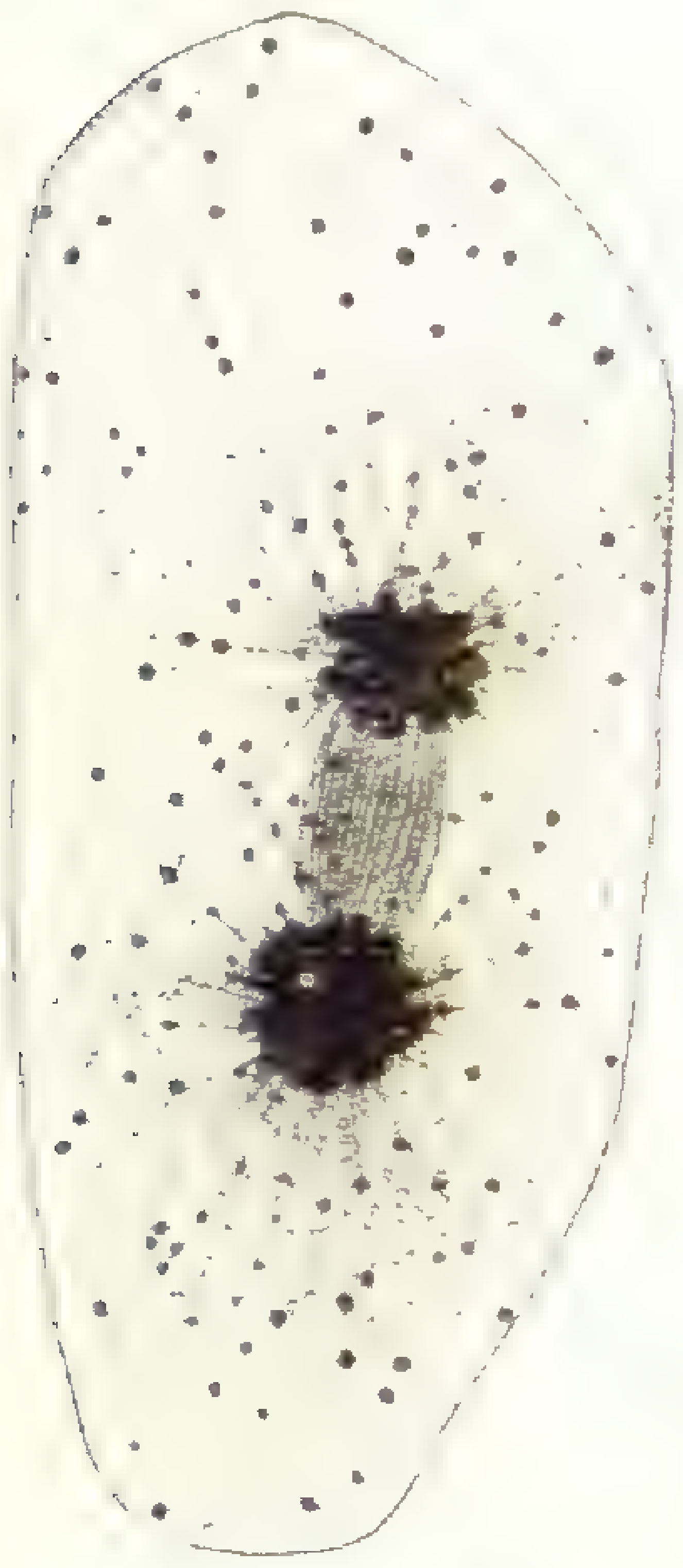
SCHAFFNER on LILIUM.



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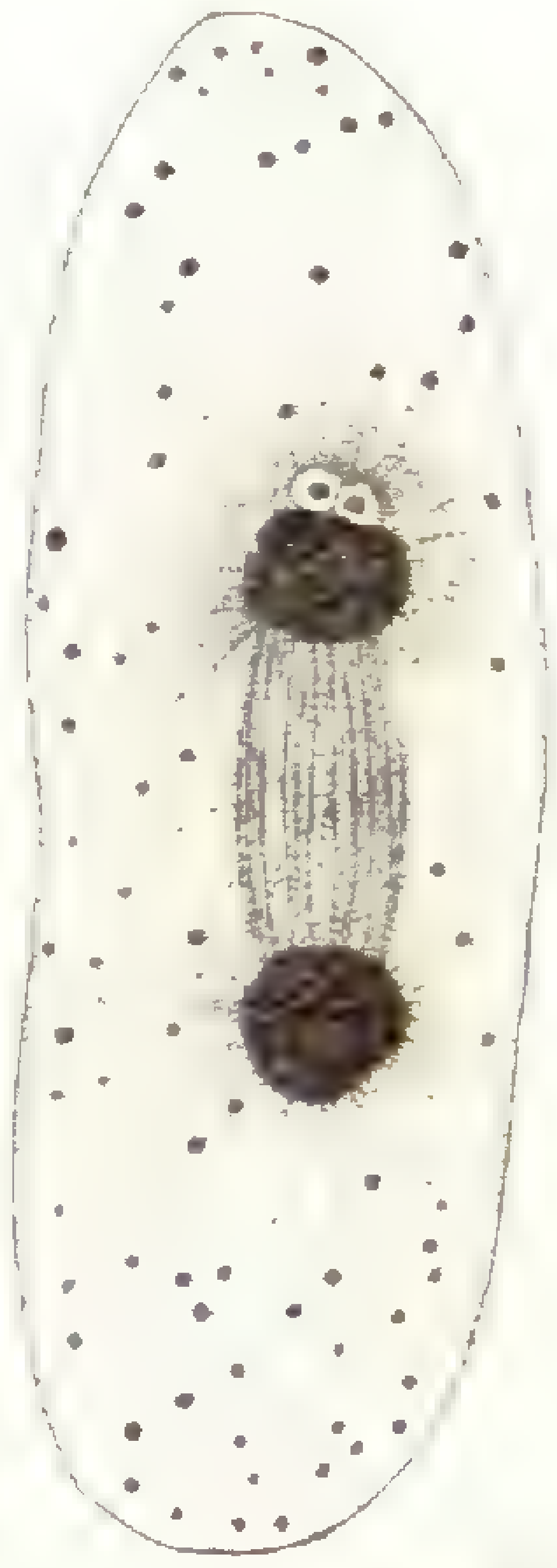

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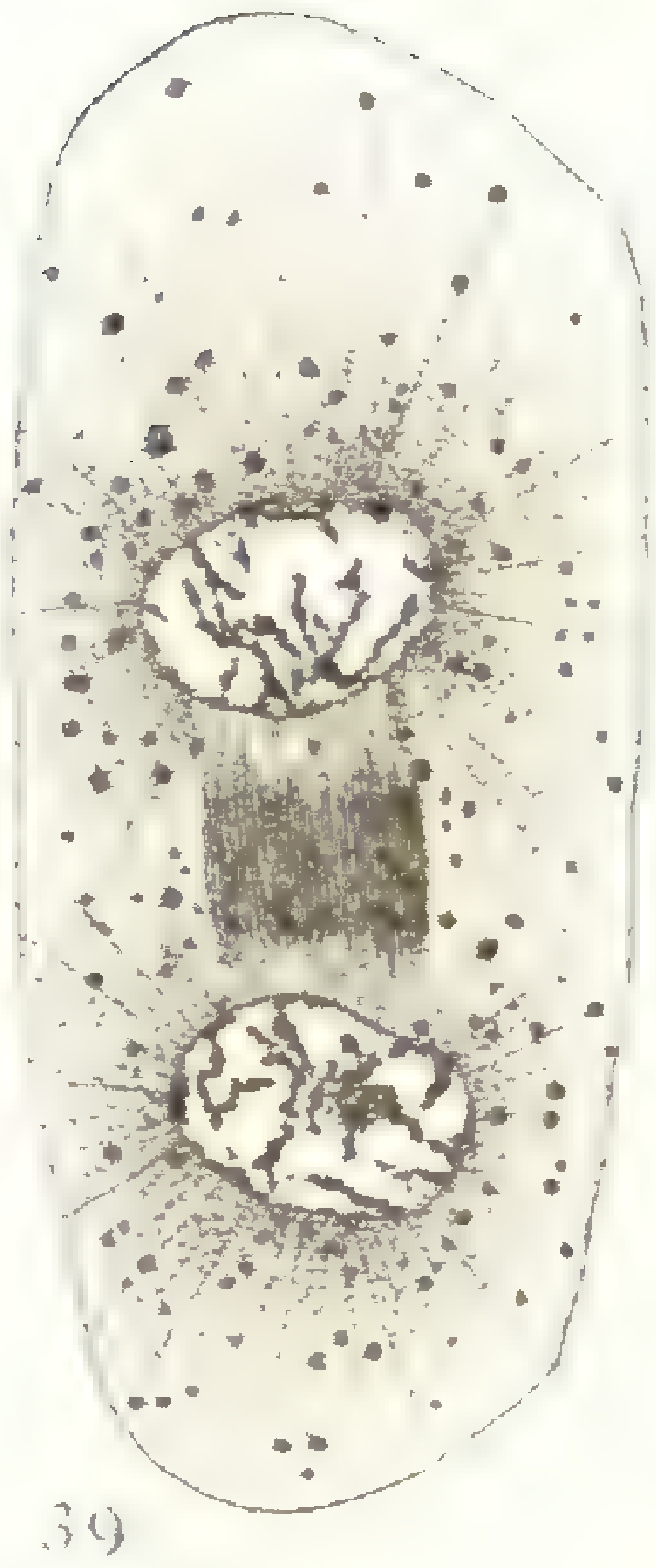

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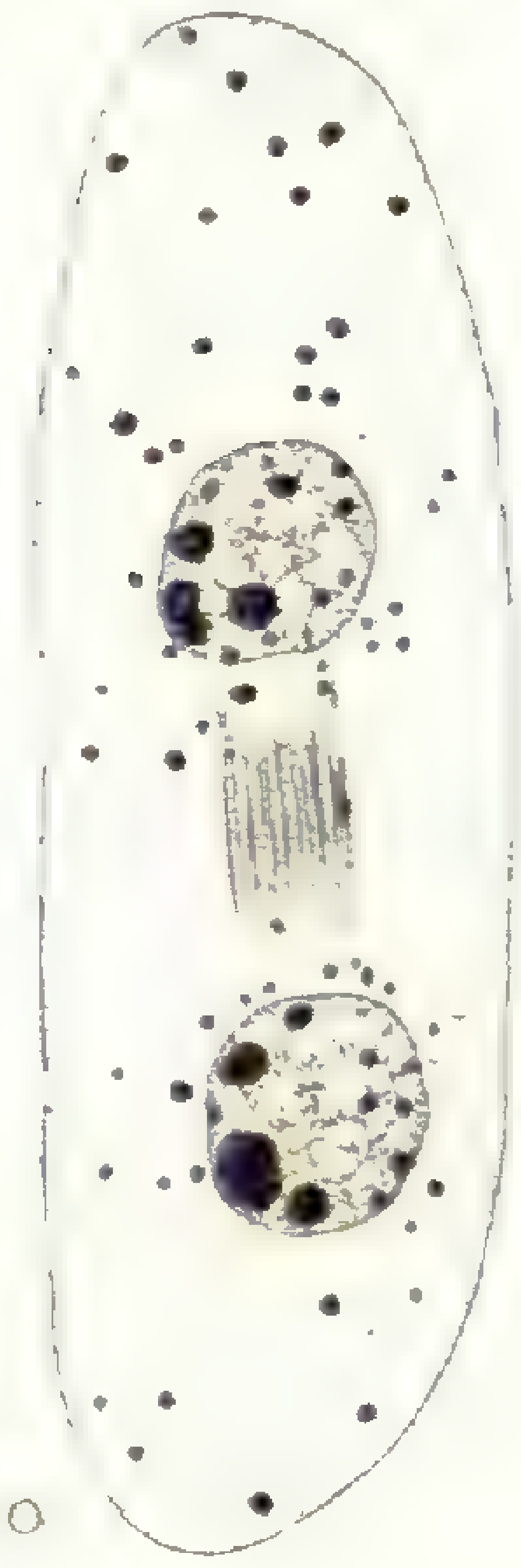

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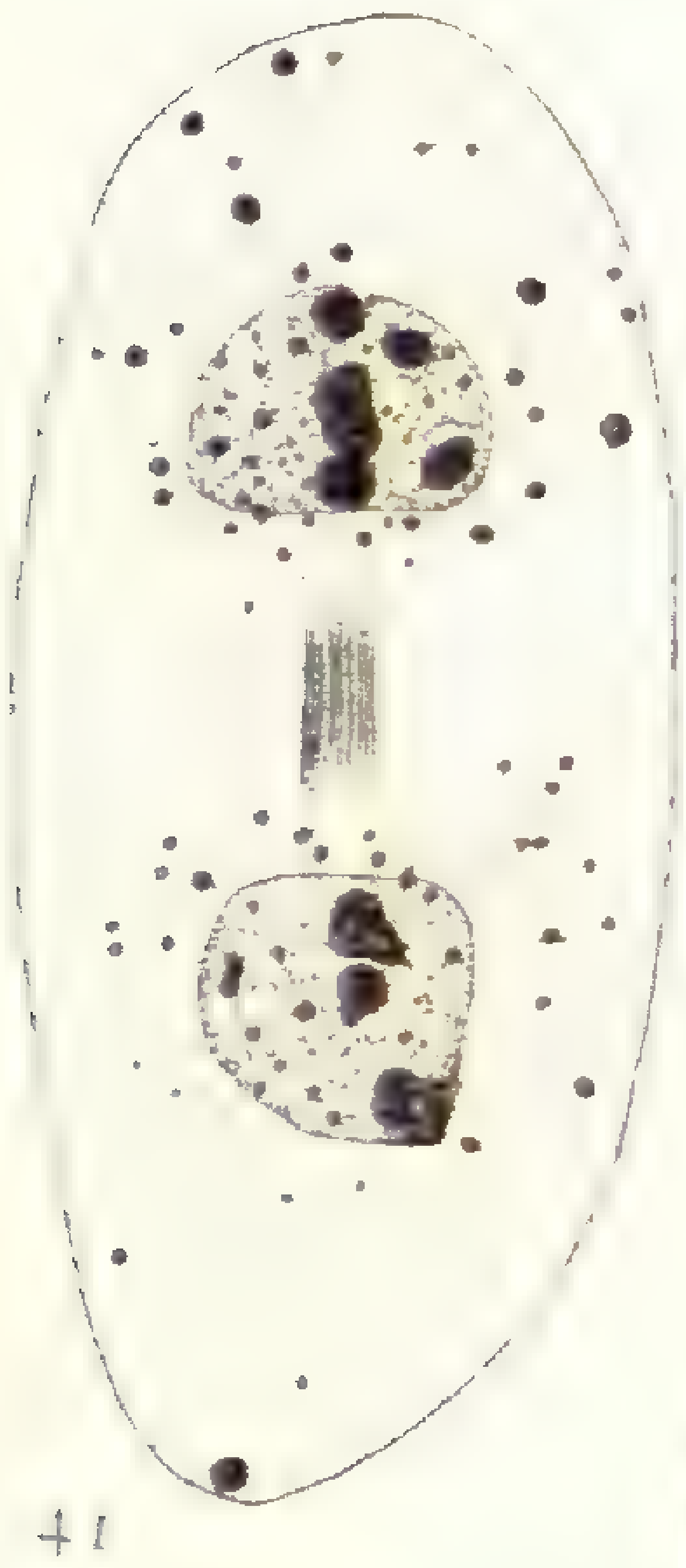

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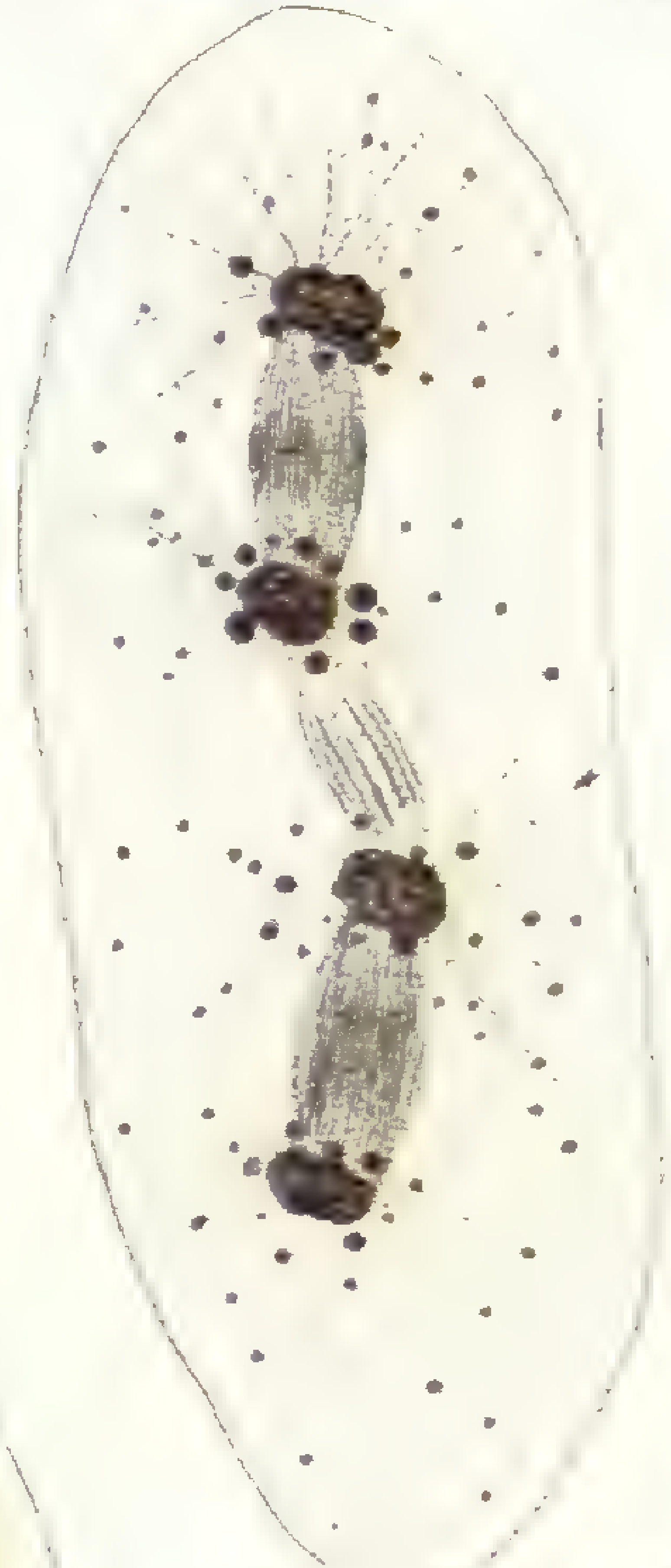

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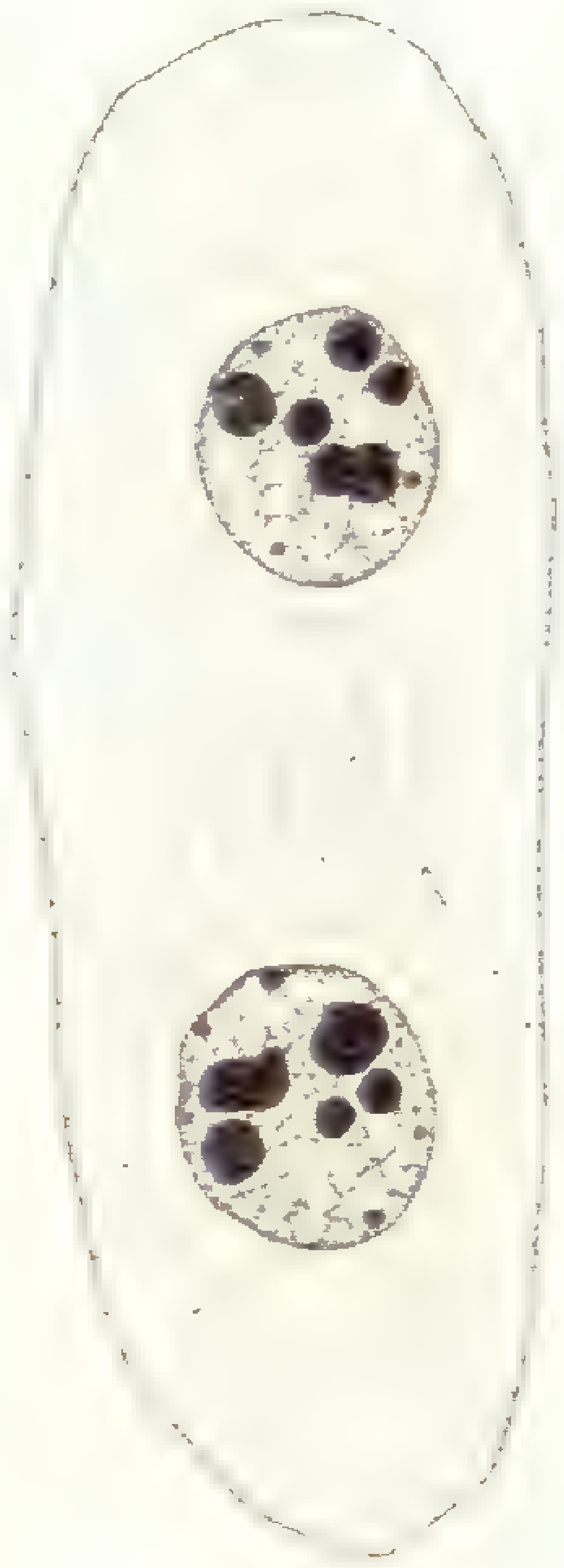

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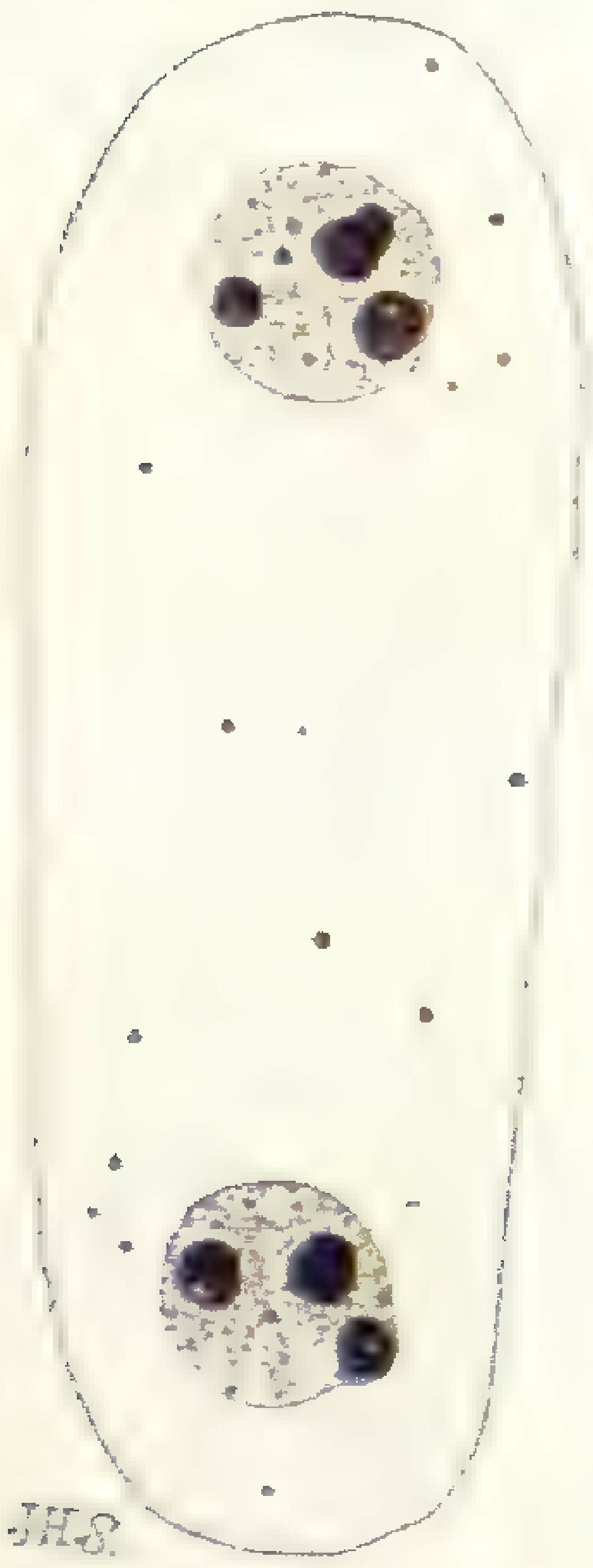

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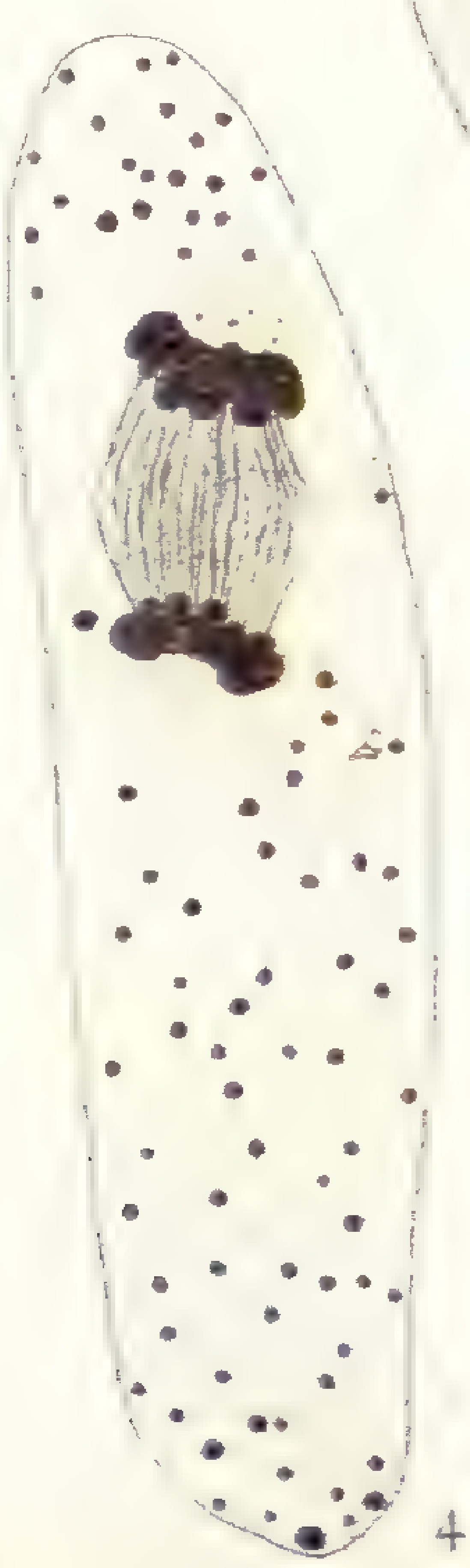

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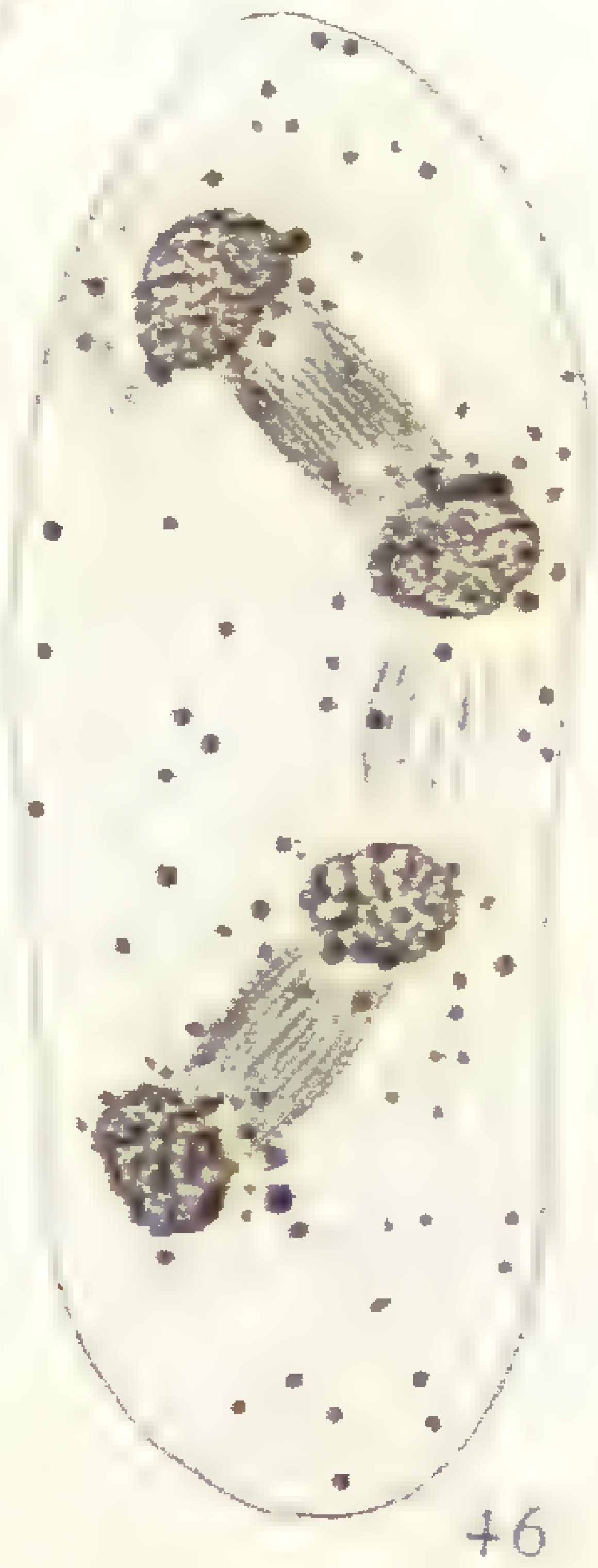

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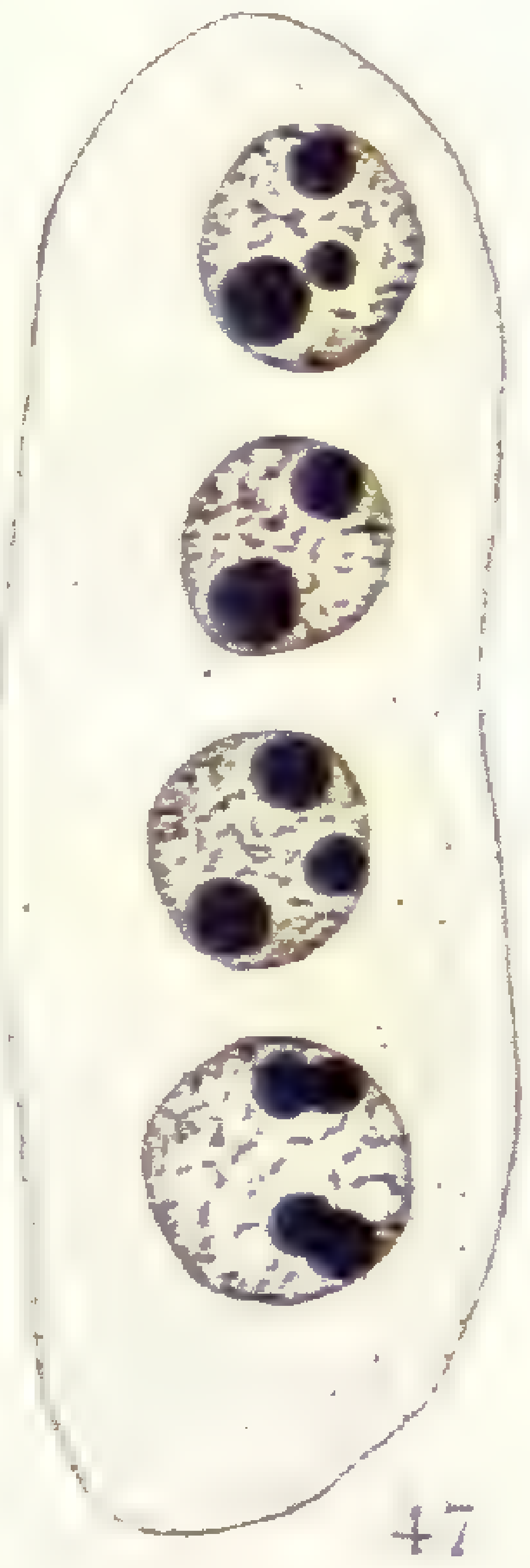

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SCHAFFNER on LILIUM.

FIG. 21. Nucleus, showing twelve developing chromosomes. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 21*a*. A single chromatin loop showing the double arrangement of the chromatin granules. × 2250.

FIG. 22. Section of nucleus with five chromosomes and a vacuolate nucleolus. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 22*a*. Adjoining section of the same nucleus showing the remaining chromosomes, five of which are clustered around a nucleolus. × 1200.

FIG. 23. Section of a nucleus, showing seven chromosomes. The chromatin loop is covered with a thick layer of material, which is stained a light purplish red, while the chromatin band itself is a very dark purple. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 23*a*. Adjoining section of the same nucleus, showing two nucleoli and five chromosomes. × 1200.

FIG. 23*b*. A single chromosome. × 2250.

FIG. 24. Macrospore, showing twelve chromosomes and numerous micronucleoli in the surrounding cytoplasm. Delafield's haematoxylin, erythrosin. × 1200.

FIG. 25. Macrospore with twelve chromosomes and numerous micronucleoli in the surrounding cytoplasm. A little later stage than *fig. 24.* Delafield's haematoxylin, erythrosin. × 1200.

FIG. 25*a*. A single chromosome stained a very dark purple with a homogeneous appearance throughout. × 2250.

FIG. 26. Macrospore with nucleus in the mother star stage. Centrospheres at the poles of the spindle and numerous micronucleoli in the surrounding cytoplasm. Anilin-safranin, gentian-violet. × 1200.

FIG. 27. Mother star showing the arrangement of the chromosomes on the spindle threads. Iron-alum, haematoxylin. × 1200.

FIG. 28. Chromosome from mother star. Cyanin, erythrosin. × 2250.

FIG. 29. Chromosome from mother star. Iron-alum, haematoxylin. × 2250.

FIG. 30. Chromosome from mother star showing a darker central part corresponding to the position of the chromatin band. Anilin-safranin, gentian-violet. × 2250.

FIG. 31. Chromosome from mother star. Cyanin, erythrosin. × 2250.

FIG. 32. Chromosome from mother star. Cyanin. × 2250.

FIG. 33. Chromosome from mother star, showing mode of division Anilin-safranin, gentian-violet. × 2250.

FIG. 34. Chromosome from mother star, showing mode of division. Anilin-safranin, gentian-violet. × 2250.

FIG. 35. Chromosome from mother star, showing mode of division which appears to be an untwisting of the chromatin loop. Anilin-safranin, gentian-violet. × 2250.

FIG. 36. Macrospore, with nucleus in the mother star stage with numerous micronucleoli in the surrounding cytoplasm, some of which are of a larger size than usual. The chromosomes are ready to be pulled apart. Anilin-safranin, gentian-violet. × 1200.

FIG. 36*a*. Pole of the spindle with centrosphere containing a double centrosome. × 2250.

FIG. 37. Macrospore, with nucleus in the loose daughter skein stage. The numerous micronucleoli in the cytoplasm appear to be in close connection with cytoplasmic radiations surrounding the daughter nuclei. Iron-alum, haematoxylin, erythrosin. × 1200.

FIG. 38. Close daughter skein stage with numerous micronucleoli in the surrounding cytoplasm, cytoplasmic radiations, and fine centrospheres at one pole. Anilin-safranin, gentian-violet. × 1200.

FIG. 39. Close daughter skein stage with micronucleoli in cytoplasm and cytoplasmic radiations. Delafield's haematoxylin. × 1200.

FIG. 40. Close daughter skein with most of the micronucleoli inside of the nuclear area. Anilin-safranin, gentian-violet. × 1200.

FIG. 41. Close daughter skein with most of the micronucleoli inside of nuclear area and the remaining ones crowded around the two nuclei. Anilin-safranin, gentian-violet. × 1200.

FIG. 42. Two-celled embryo sac. Only a few micronucleoli remaining in the cytoplasm. Anilin-safranin, gentian-violet. × 1200.

FIG. 43. Two-celled embryo sac. All the micronucleoli have entered the daughter nuclei, which at this stage have well-defined nuclear membranes. Iron-alum, haematoxylin, orange G. × 1200.

FIG. 44. Section of two-celled embryo sac, showing nucleus in the daughter star stage. Two centrospheres appear at one pole and numerous micronucleoli in the cytoplasm. Anilin-safranin, gentian-violet. × 1200.

FIG. 45. Embryo sac with well marked cytoplasmic radiations, and the micronucleoli crowded around the daughter nuclei. The remains of the first division spindle are still present. Cyanin, erythrosin. × 1200.

FIG. 46. Embryo sac with the two nuclei in the close daughter skein stage. Numerous micronucleoli in the surrounding cytoplasm and the remains of the first division spindle. Anilin-safranin, gentian-violet, × 1200.

FIG. 47. Four-celled embryo sac with all the nuclei in the resting stage, showing parietal position of the nucleoli. No micronucleoli are left in the cytoplasm. Anilin-safranin, gentian-violet. × 1200.

PECULIAR STRUCTURES OCCURRING IN THE POLLEN TUBE OF ZAMIA.

HERBERT J. WEBBER.

(WITH PLATE XL)

THE recent announcement by Hirase[1] of the occurrence of motile spermatozoids in *Ginkgo biloba*, and that by Ikeno[2] of the occurrence of similar organs in *Cycas revoluta*, render any observations on the phenomena occurring in the pollen tube of Zamia, belonging to the related sub-family Zamieæ, of special interest. In cones of *Zamia integrifolia* shortly before fecundation the writer has observed several remarkable structures, which, so far as can be learned, have never been described.

For a considerable period preceding fecundation in Zamia, as in many other gymnosperms, the pollen tube apparatus remains in almost the same condition. no important changes taking place. In this stage the pollen grains, which lie in the pollen chamber at the apex of the nucellus, are found to have germinated and the germ tubes to have reached a length of 1 to 2^{mm}, penetrating into the tissue of the nucellus. The pollen tube is much greater in diameter than the pollen grain which may be clearly distinguished. The vegetative nucleus of the pollen grain, in every case observed, has wandered into the pollen tube and may usually be found near its lower end (*fig. 1*). In the upper end of the pollen tube, near the pollen grain, two cells are uniformly found, one in close connection with the old pollen grain from which it protrudes or is only slightly separated, and the other immediately in front of this in the more swollen portion of the pollen tube (*fig. 1*). The former cell is spherical or slightly elongated and presents a most singular structure. The nucleus of the original cell evidently divides into two, and one of the daughter nuclei forms within the unbroken *Hautschicht* of the mother cell a new and wholly distinct *Hautschicht* which delimits a cell lying entirely free within the mother cell and surrounded on all sides by a layer of protoplasm of nearly uniform thickness (*figs. 1a* and *2*.) The other daughter nucleus remains free within the *Hautschicht* of the mother cell, but is pressed to one side by the interior cell. The free nucleus usually occupies the side of the mother cell opposite the pollen grain. Both the interior cell and the mother cell are crowded full of small spherical starch grains (*fig 2*). The second cell (*fig. 1 gc*) which is probably to be compared with the generative cell in conifers, is much larger then the first or proximal cell above described, and is provided with two small spherical organs, situated at the opposite ends of the nucleus outside the nuclear wall, that somewhat resemble centrosomes (*fig. 3*). They are exactly spherical and stain deep red with safranin, in the Flemming triple stain process, much as the nucleoli. There is no appreciable difference in size between the spheres in the same cell, but those of different cells frequently vary several micromillimeters in diameter, ranging from 7 to 10 μ. Many of the spheres at this stage appear entirely homogeneous, but in some cases a number of small vacuoles have been observed in the interior (*fig. 4*). Numerous long slender threads of kinoplasm radiate in all directions from the spheres, and in many instances may be seen plainly to extend to the *Hautschicht* with which they frequently appear to unite. The threads of kinoplasm are rather coarse and are plainly visible without staining. With the Flemming triple stain they are colored intensely blue. They appear in many instances to be firmly fastened to the *Hautschicht*, which is drawn in more or less where the thread is attached (*fig. 5*). This seeming indentation may, however, be caused by shrinkage during fixing and staining. The spheres are usually 7 to 10 μ from the nuclear wall, which is in most instances strongly indented on the ends next to the spheres. Threads of kinoplasm run from the spheres to the nuclear wall, which at this stage is apparently continuous. In most cases observed the spheres occupy positions on exactly opposite sides of the nucleus, but in a few instances they have been found much nearer together, being only about 135° apart. The nuclei which these bodies accompany are at this stage in a resting condition, the contents presenting a fine granular appearance and usually showing foam-structure more or less plainly. The nuclei are usually elliptical and about 80 μ long by 56 μ wide. The large nucleoli (20 to 24 μ in diameter) contain numerous vacuoles. Frequently several other small nucleoli may be observed in a nucleus.

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[1] HIRASE, S. — Untersuchung über das Verhalten des Pollens von Ginkgo biloba. Bot. Centralbl. 69: 33. 14 Ja. 1897.

[2] IKENO, S. — Vorläufige Mittheilung über die Spermatozoiden bei Cycas revoluta. Bot. Centralbl. 69: 1. 30 D. 1896.

When the activity, which precedes fecundation, begins, the generative cell does not wander down to the distal end of the pollen tube as might be expected from analogy, but instead the proximal end of the tube (the pollen grain end) with the two cells, shown in *fig. 1*, turns directly downward and grows through the apical tissue of the nucellus (*fig. 6*) and may be seen with a hand lens hanging down into the cavity formed above the archegonia. The pollen grain, constituting the extreme end of the now pendent proximal end of the tube, may be plainly seen, the two cells remaining in the same relation to the pollen grain as shown in *fig. 7*. All of the tubes examined show this same structure, indicating that it must be the normal procedure. The first cell which protrudes from the old pollen grain remains in the same condition, or in the most advanced stages yet studied shows indications of disintegration. The generative cell or second cell in the tube, which now lies above the first cell, has usually divided during this extension of the tube, or may be found in some stage of division. The two centrosome-like bodies which accompany each generative cell and during the resting condition, as described above, occupied the poles of the nucleus corresponding to the major axis of the cell and the longitudinal axis of the pollen tube, usually come to lie, during the migration of the cell into the now extended proximal end of the pollen tube, at two opposite points on the equator, the nucleus corresponding to the minor axis of the cell or transversely in the pollen tube. Whether this change in their position is brought about by the migration of the centrosome-like bodies or by the changed position of the nucleus the writer has not yet been able to surely determine. They have meanwhile greatly increased in size, now measuring usually from 18 to 20 μ in diameter. They now have a clearly distinguishable outer wall of considerable thickness and the contents are evenly and beautifully vacuolate.

When the nuclear spindle is formed these bodies always take up a position directly opposite the polar ends. In the monaster stage of the division (*fig. 7*) the spindle, which occupies a transverse position both to the pollen tube and to the elliptical nucleus, is composed of fine kinoplasmic filaments and seems to be entirely within the still preserved nuclear wall. It is blunt poled, if indeed it is not multipolar, and does not seem to have any kinoplasmic connection with the centrosome-like bodies. In the resting condition of the nucleus the centrosome-like bodies were surrounded by radiating threads of kinoplasm, but no indications of these can now be seen. There is, however, in most cases a slight radial arrangement of the protoplasm immediately bordering the wall. The structure of the bodies has meanwhile undergone considerable change (*figs. 7, 8*). The wall swells up and apparently separates into fragments which in cross-section at this stage show as a broken line. The vacuolated contents meanwhile contract away from the wall, leaving a clear space intervening, which is, however, traversed by a few slender filaments. The body at this stage presents the appearance of disintegration.

When the cell-plate is formed (*fig. 9*) the centrosome-like body is found entirely broken up, the fragments appearing in the cytoplasm as a number of granules mixed with plates or membranes which appear to be fragments of the wall. After the new cell wall is completed and the daughter nuclei have returned to the resting stage, showing a nucleolus, the fragments of the broken-down centrosome-like body present the appearance shown in *fig. 10*. A little cluster of granules appear in the exact location of the body, and the plates, which stain deeply and often appear to be two in number, have separated and moved toward the poles of the daughter nuclei.

The writer has been unable to determine the origin of the centrosome-like bodies described above, and thus cannot be sure as to their nature. In the resting condition of the generative cell (*fig. 3*) they are somewhat similar to the bodies described by Hirase as "attraction spheres"[3] in the pollen cell of *Ginkgo biloba*, but his description and figure differ from what I have seen, in that spherical bodies much larger than the attraction spheres are located between them and the nucleus. No indications of the latter body occur in Zamia. The nucleus, furthermore, is of very different shape from those occurring in my slides of Zamia, and the so-called attraction spheres are apparently much smaller than the similar bodies which I find.

The researches of Farmer,[4] Osterhout,[5] Mottier,[6] and Strasburger[7] have thrown much doubt on the occurrence of centrosomes in the pteridophytes and phanerogams, where the nuclear spindle in its earlier stages is multipolar, at least in the spore or pollen mother cells. In view of these facts their occurrence in Ginkgo and Zamia may well be doubted. The spheres in the generative cell of Zamia resembles centrosomes in that they have the kinoplasmic filament centered upon them during a large part of their existence, and have an important relation to the formation of the spindle, being uniformly located near the poles and always having a definite orientiation with reference to the axis of the spindle. They differ, however, so materially from the centrosomes described by Farmer,[8] Swingle,[9] Strasburger,[10] and others, and from the centrospheres found by Harper[11] in the Ascomycetes, that in the present state of our knowledge they must be considered to be distinct organs. What they are cannot be determined till their origin and functions are better known.

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[3] HIRASE, S.—Notes on the attraction sphere in the pollen cells of *Ginkgo biloba* The Botanical Magazine **8**: 359. 1894.

[4] FARMER, J. BRETLAND.—Ueber Kerntheilung in Lilium-Antheren besonders in Bezug auf die Centrosomen-Frage. Flora **80**: 56. ——.

[5] OSTERHOUT, W. J. V.—Ueber Enstehung der karyokinetischen Spindel bei Equisetum. Jahr. f. wissenschaft. Bot. **30**: 159. 1897.

[6] MOTTIER, DAVID M.—Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen einiger Dikotylen und Monokotylen. Jahr. f. wissenschaft Bot. **30**: 169. 1897.

[7] STRASBURGER, EDUARD.—Ueber Cytoplasmastructuren, Kern- und Zelltheilung. Jahr. f. wissenschaft. Bot. **30**: 375. 1897.

[8] FARMER, J. BRETLAND.—On spore formation and nuclear division in the Hepaticæ. Annals of Botany **9**: 469. 1895.

The further highly remarkable history of these organs the writer hopes soon to discuss, together with other details of the fecundation, in a future number of this journal.

U. S. SUBTROPICAL LABORATORY,
EUSTIS, FLORIDA.

NOTE.— As this paper is passing through the press Mr. Webber sends word that he has discovered motile antherozoids in Zamia. They were found in a sugar solution and kept moving for two hours and forty-four minutes.— EDS.

EXPLANATION OF PLATE XL.

Zamia integrifolia Willd.

FIG. 1. Pollen tube growing in the nucellus of the ovary; *pg*, pollen grain; *vn*, vegetative nucleus; *a*, cell protruding from old pollen grain and containing a free interior cell and nucleus; *gc*, generative cell. × 120.

FIG. 2. Proximal cell shown at *a* in preceding figure. × 550.

FIG. 3. Generative cell showing centrosome-like bodies with radiating filaments and kinoplasm. × 450.

FIG. 4. Centrosome-like body during resting stage of nucleus, showing vacuoles. × 1800.

FIG. 5. Centrosome-like body seen from above looking toward the nucleus showing kinoplasmic filaments connected with *Hautschicht*. × 600.

FIG. 6. Diagrammatic outline of the upper end of nucellus, showing the proximal end of the pollen tubes growing down into the cavity just above the archegonia; *p*, prothallus; *a*, archegonia; *pc*, pollen chamber; *pt*, pollen tubes; *pg*, pollen grain.

FIG. 7. Generative cell in monaster stage of division, showing the breaking down of the centrosome-like body and the absence of the radiating kino-

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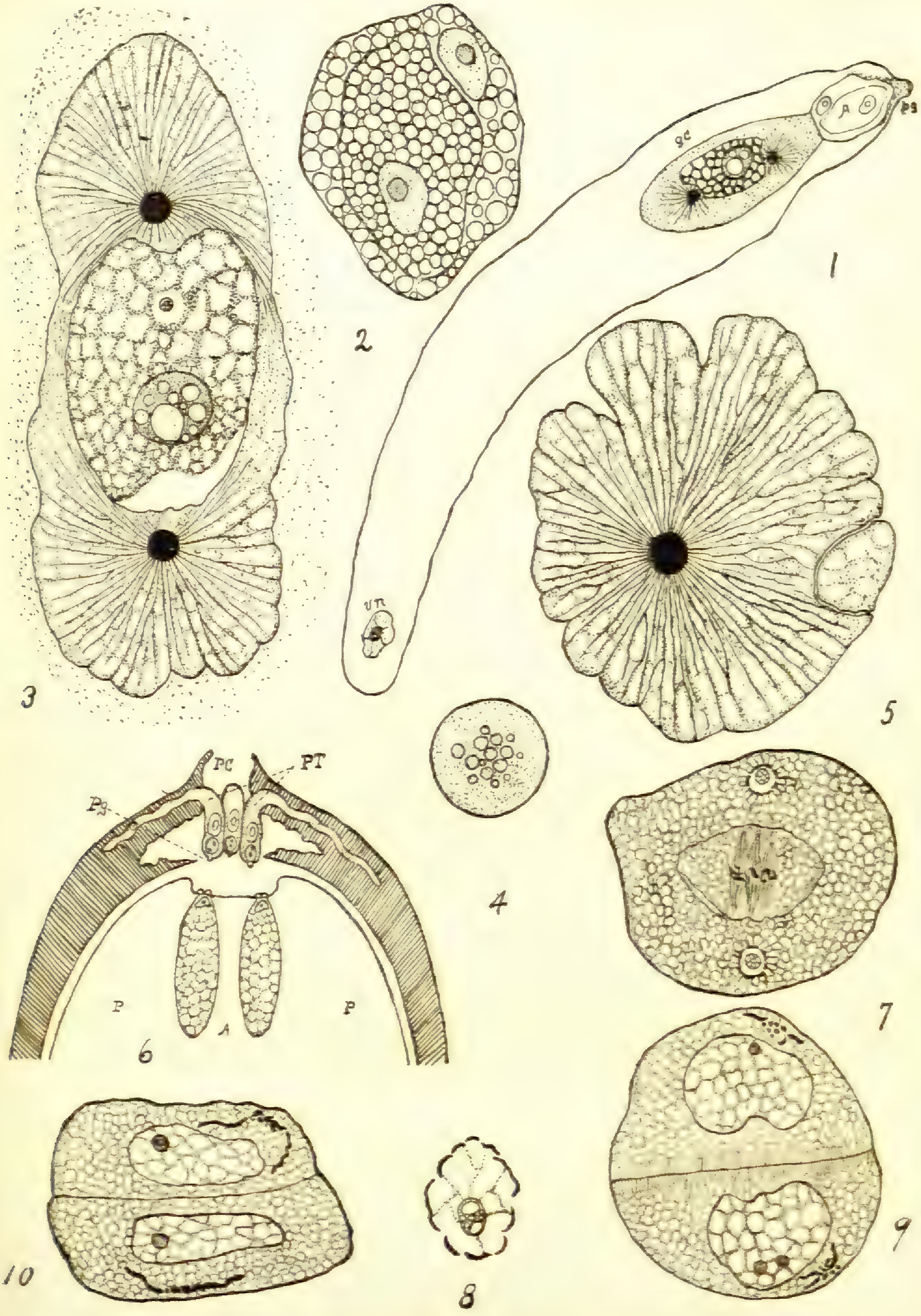
[9] SWINGLE, WALTER T.— Zur Kenntniss der Kern- und Zelltheilung bei den Sphacelariaceen. Jahr. wissenschaft. Bot. **30**: 297. 1897.

[10] STRASBURGER, EDUARD.— Kerntheilung und Befruchtung bei Fucus. Jahr. f. wissenschaft. Bot. **30**: 351. 1897.

[11] HARPER, R. A.— Kerntheilung und freie Zellbildung in Ascus. Jahr. wissenschaft. Bot. **30**: 249. 1897.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PC
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WEBBER on ZAMIA.

plasmic filaments which surrounded it in the resting condition of the cell. × 200.

FIG. 8. Centrosome-like body from cell illustrated in *fig. 7*. × 600.

FIG. 9. Generative cell in late stage of division, showing the fragments of the centrosome-like body. × 200.

FIG. 10. Generative cell after division with the fragments of the centrosome-like bodies showing the plates or membranes approaching the poles of the daughter nuclei. × 200.

BRIEFER ARTICLES.

CURIOUS LEAVES.

The leaves of trees not infrequently present sports or deviations from the ordinary types characteristic of the species, and occasionally these sports are of botanical interest. A few collected near Dayton, Ohio, during the autumn months of last year, are here figured.

A twig from an American elm has a terminal leaf with its basal margins grown together, forming a short funnel-like cavity, with a very oblique upper rim. The third last leaf presents a similar funnel-like cavity at its base, but the leaf blade is supplied with two midribs and leaf tips. The second last leaf shows two midribs and leaf tips, but the basal margins of the leaf blade have remained separate (*figs. 1, 2*).

Near the tip of a young shoot from a stump of the white ash were small leaves with the usual pointed leaflets. In the figure (*fig. 3*) all but one of these leaves have been removed. The next lower pair of leaves, however, has most of the leaflets notched at the tip. The most interesting one of these is the terminal leaflet of the right hand leaf, which, although slightly notched at the tip, bears itself a second terminal leaflet pointed in the usual way.

A third sport occurred in the leaves of some of the minor branches of the ordinary dogwood (*fig. 4*). Here the leaves instead of being pointed in the usual way have assumed the form of the involucral bracts which are taken by the unwary for the petals of the flower. Their color, however, was green.

A study of numerous sports of this kind has developed the following facts: In trees with opposite leaves it rarely happens that only one leaf of a pair deviates from the type form. Usually both leaves show the same, or at least similar variations. In the case of both trees with opposite and those with alternate leaves several successive nodes usually show either the same or similar variations. Several of the neighboring branches, and even branches of neighboring trees, may present the same variation, but in those cases the variations seem

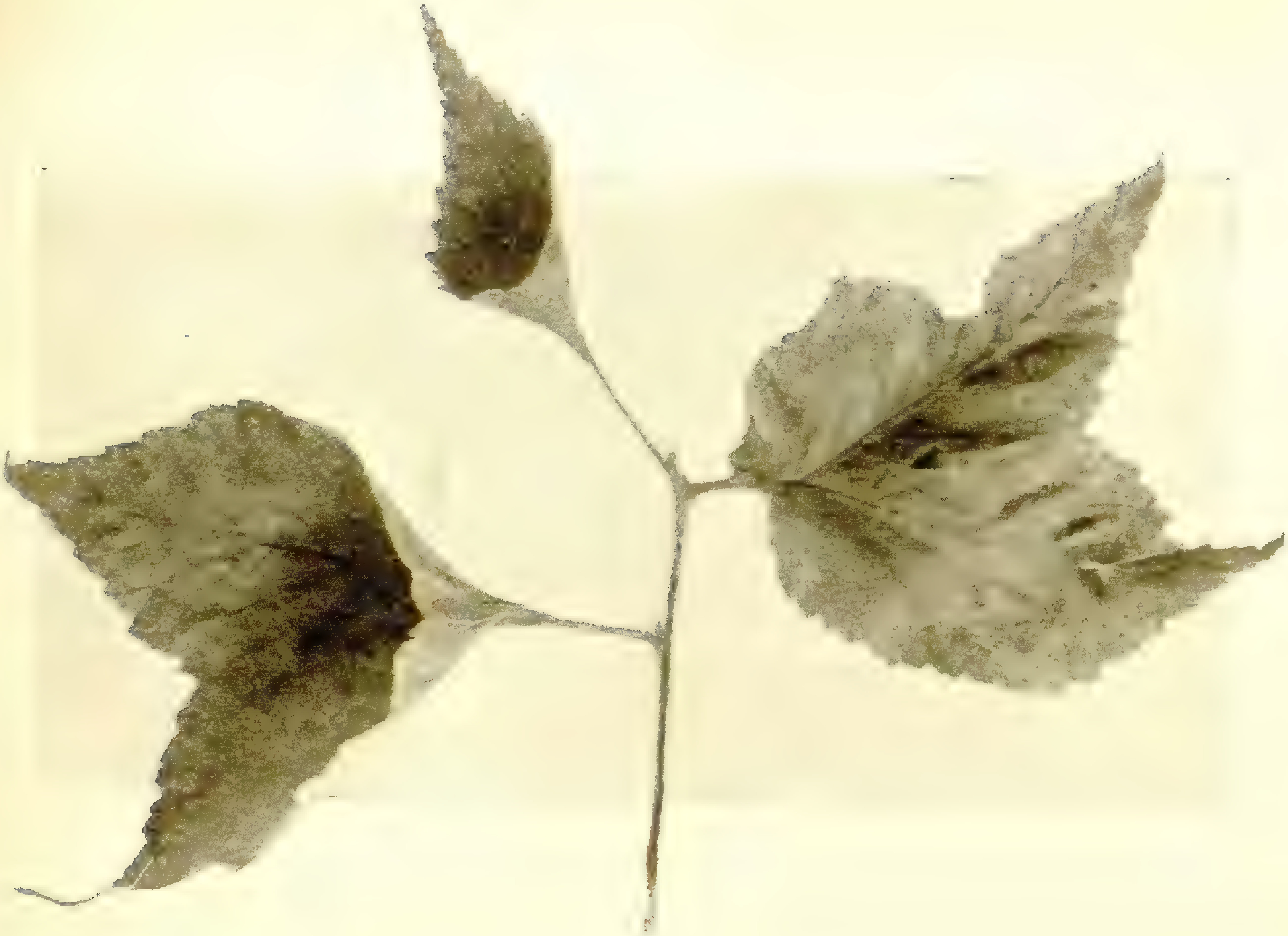

FIG. 1.

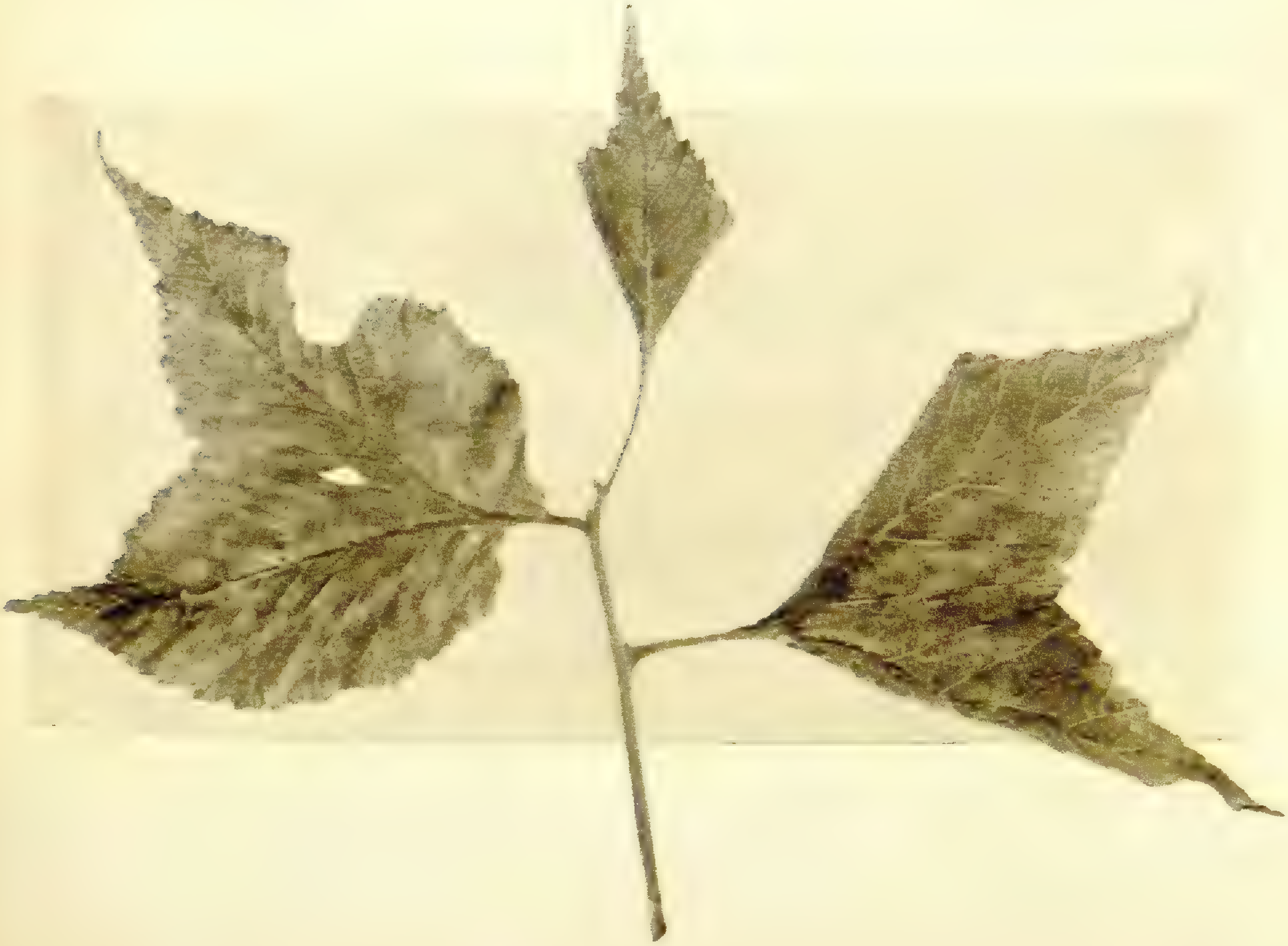

FIG. 2.

to have been very nearly synchronous, judging by the position of the sports along that part of the branches formed during the year.

The appearance of similar sports along successive internodes has led to the belief that each node and its appendages may be considered a plant unit of which the next node is an offspring. In this sense the successive appearance of similar sports along the same branch may be looked upon as a case of heredity. The simultaneous appearance of similar sports in neighboring branches or trees, however, indicates that this explanation is not sufficient. In order to arrive at a proper basis for the interpretation of these facts it is necessary to know the life history of the plant. For instance, at what time of the year does the elm leaf begin to differentiate its cells into those which shall become a part of the midrib, and those which shall not? At what time of the year do the leaf blades begin their development? When are the forms of the tips of ash and dogwood leaves determined? Is it not during the vicissitudes of autumn, the winter months, and very early spring? It is believed that a further study of this subject will indicate that freaks of a marked kind often accompany very marked meteorological irregularities, and that there is often a vital connection between the two.

In a similar manner it has been noticed that ash twigs with three leaves at a node are formed more commonly on the young shoots which spring up from the stump of the tree the first year after the tree has been cut down. In other words, while we know as yet very little about the conditions which give rise to sports, it is beginning to be evident that even these evanescent freaks of nature stand in relationship to other conditions as cause and effect: that they are sporadic attempts on the part of nature to accommodate itself to variant conditions at present ill understood.

These sports belong, perhaps, to the same order as those peculiar sports among gold fish so popular with the Chinese, gold fish with tripartite tail, caused, it is said, by shaking up the eggs of fishes violently before they are hatched.—AUG. F. FOERSTE, *Dayton, Ohio.*

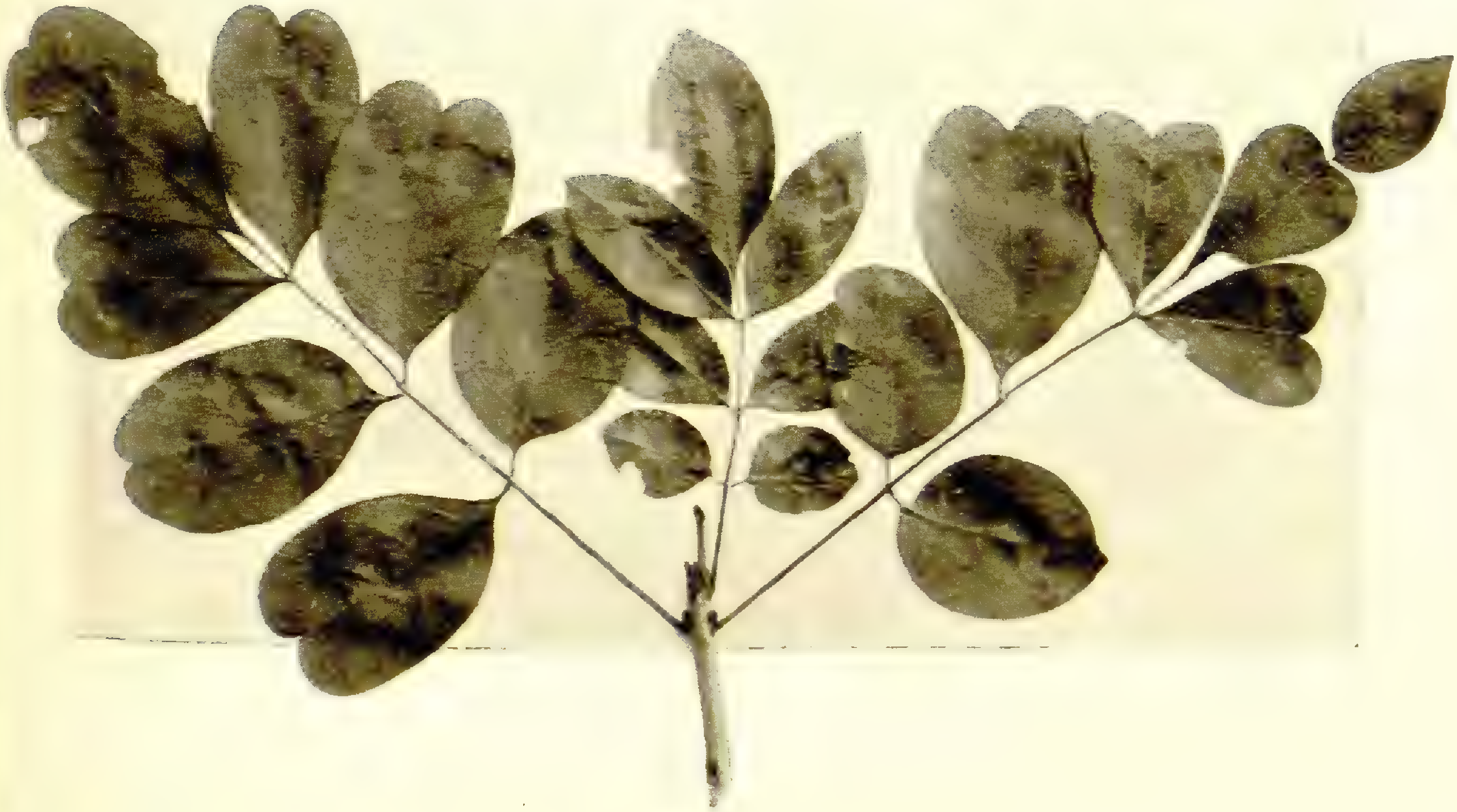

FIG. 3.

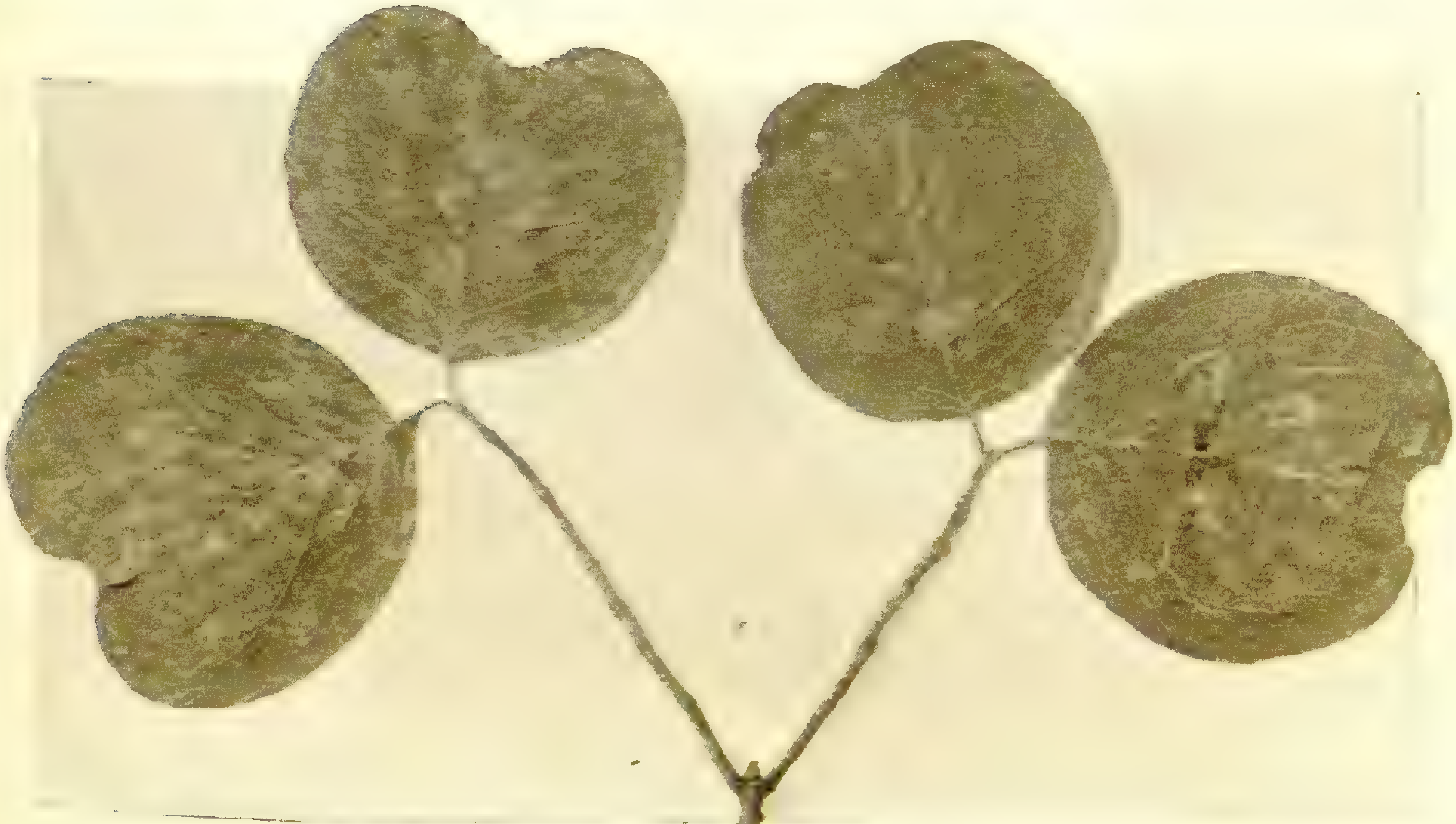

FIG. 4.

OPEN LETTERS.

SPECIES OF BOTRYCHIUM.

To the Editors of the Botanical Gazette:—In the second edition of *Gray's Manual of Botany* (1856), and continued in the third and fourth editions, under the species *Botrychium Virginicum* occurs this remarkable statement:

> "Var.? *simplex* (*B. simplex*, Hitch.) appears to be a remarkably depauperate state of this, only 2′–5′ high, the sterile frond reduced to a single short-stalked division, and simply or doubly pinnatifid," etc.

I cite the above to show that the practice of reduction of distinct species of Botrychium is one that has long been followed beyond the river Charles.

There are to my knowledge three general accounts of the genus Botrychium that have appeared within the past thirty years, and as they differ somewhat widely I reproduce the disposition of species in each case. In the last column a double star indicates the species accredited to our territory.

Milde, 1868, 1869, 1870[1]	Baker, 1874; reiterated, 1891[2]	Prantl, 1884[3]
1. B. Lunaria Sw.	1. B. simplex Hitch.	1. B. Lunaria Sw.**
2. B. crassinervium Rupr.		
3. B. boreale Milde.		2. B. boreale Milde**
4. B. matricariaefolium A. Br.	2. B. rutaceum Sw.	3. B. lanceolatum Angs**
5. B. lanceolatum Angs.		4. B. matricariaefolium A. Br.**
6. B. simplex Hitch.	3. B. Lunaria Sw.	5. B. simplex Hitch.**
		6. B. ternatum Sw.
		7. B. daucifolium Wall.
		8. B. subbifoliatum Brack.
7. B. ternatum Sw.	4. B. ternatum Sw.	9. B. australe R. Br.
8. B. daucifolium Wall.	5. B. daucifolium Wall.	10. B. silaifolium Presl.*
		11. B. obliquum Willd.**
		12. B. lunarioides Sw.**
		13. B. rutifolium A. Br.
9. B. lanuginosum Wall.	6. B. Virginianum Sw.	14. B. lanuginosum Wall.
10. B. Virginianum Sw.		15. B. Virginianum Sw.**

The first record of the *ternatum* group from America appears to have been that of Lamarck's species 1797 (*Osmunda biternata*), which was re-described by Michaux in 1803 (*Botrypus lunarioides*) under another name. In Pursh's Flora (1814) there was introduced a confusion which continued until the modification of Milde's arrangement which appeared in the sixth edition of *Gray's Manual of Botany*. That Milde fell into Pursh's error of confusing various Atlantic forms under Michaux's name is perfectly evident from his text:—(1) Milde's description of *lunarioides* is generalized and indefinite, and while it may well cover a great variety of forms it does not at all delimit the very distinct *Botrychium biternatum* (Lam.); (2) from his quotation, or rather translation, of the range given by Pursh: "Auf Triften und in lichten Wäldern von New York bis Carolina (Pursch);" (3) from his later citation of additional localities for the plant from Lake Superior (Macoun) and Montreal (Watt) which, as all northern forms were at that time confused under the name *lunarioides*, Milde evidently either quoted from some published list or may have received specimens and quoted the current labels; if the latter more the pity. There is nothing more certain than that Milde did not at all understand the very unique character of the exclusively southern plant, and Mr. Davenport's statement, "I cannot believe it possible for him to have been mistaken in any specimens coming under his observation," reminds one more of sentimental hero worship than of a sincere attempt to know the truth. The citation of "authority" and "the opinion of the fathers" is as obsolete in botany as it is elsewhere. It does not surprise me that Mr. Davenport has sought in vain to find anything approaching *lunarioides* in Professor Macoun's collections. The collections of the past sixty years in northern areas has failed to bring it to light, and it is not likely that it exists.

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[1] Verhandl. k. k. zool. bot. Ges. Wien **18**: 507–516: **19**: 55–190: **20**: 900–1002.

[2] Synopsis Filicum 447, 448. 1874; Ann. Bot. **5**: 500. 1891.

[3] Jahrb. des kön. bot. Gartens, Berlin **3**: 297–350. 1884.

Mr. Davenport's paper well illustrates the dilemma he is in in attempting to refer accurately to any one *thing* in his various references to *Botrychium ternatum*. At one time he is talking of one thing, and in a later sentence of another entirely different. This aggregate consists of several very distinct things, *i. e.*, distinct species, and to continue to refer to the aggregate as *one* is both confusing and unscientific.

In Mr. Davenport's zeal to reduce the species to varietal rank he seemed to overlook my statement that "the true *Botrychium ternatum* is comparatively common in central Alabama and produces its spores late in the season (August to October), the same as it does farther north[4]," and his effort to extend the season of the two species so that their extremes will not seem so widely separate must excite a smile among persons thoroughly familiar with the plants in the field. So far as I can see, the only point that Mr. Davenport has established is that the bud of some specimens of *Botrychium biternatum* is somewhat hairy (if, indeed, he is sure of his specimens, some of which I regard as very doubtfully true *biternatum*), and I fully agree with him in regarding the bud character in the genus, which he has formerly made so much of, as a somewhat unreliable one. I still regard the form which Lamarck first described as *Osmunda biternata* as distinct a species of Botrychium as exists in the country. I am, however, open to evidence, and request that during the present season observers in all parts of the country note the variations in this interesting group and send me material illustrating all the variations in their respective localities.

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[4] BOT. GAZ., **22**: 408. N. 1896.

So long as my own field observations on Botrychium were confined to central New York and New England, I regarded all the forms that there appear as running into each other and so discarded the "varieties" as trivial. I had never, indeed, until last season seen in the field the genuine form that Sprengel long ago described as *Botrychium dissectum*, a type that sixteen years of collecting in New England, and a large array of material from all parts of that territory, has not revealed as a New England form. Mr. Davenport's statement that it is a common New England form only reveals the fact that he is confusing with it a very different plant which *is* common in New England and elsewhere, but has little in common with the genuine *dissectum*. Had I experienced the misfortune to have my field work confined to eastern Massachusetts I might even yet be holding Mr. Davenport's ultra conservative notions. As it is, I believe now that while the evidence is not all in, the present indications are that Prantl's arrangement of the American species is far more logical than any other arrangement that has yet appeared, and that we have in America in the *ternatum* group a series of species even more distinct when rightly understood than the species of that other closely allied group that Baker so unceremoniously and illogically places under the aggregate "*Botrychium rutaceum* Swz."[5] I am anticipating the pleasure of soon going over the evidence at Kew and the types at Paris, and shall hope that a still wider range of data will help us to arrive at a better understanding of the genus.

It is unnecessary to discuss further Mr. Davenport's position, for his mind was fully made up in advance, since he wrote me some time ago that "Milde had said the last word on Botrychium, as though any problem of taxonomy could be settled by an appeal to "authority," and before the evidence was all in.—LUCIEN M. UNDERWOOD, *Columbia University*.

COLOR IN PLANTS.

To the Editors of the Botanical Gazette:—In your issue of January 1897 there is a notice of Professor Wittrock's studies on the history and origin of the garden pansy, at the conclusion of which is the following pregnant sentence, viz.: "If the pollinating insects prove to be color-blind, as is claimed now by certain physiologists, the yellow eye, as well as all floral coloration, will need a new explanation."

I venture to point out that such a new explanation is suggested in an article entitled "Organic color," which appeared in *Science*, June 16, 1893, published in New York. If any scientist who feels interested in the subject would consider and criticise that paper a useful discussion might ensue.—F. T. MOTT, *Crescent House, Leicester, England*.

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[5] It is worth noting that recent European monographers follow Prantl in separating the European species (*B. rutifolium*) from the *ternatum* muddle in which Milde left it. *Cf., e. g.*, Luerssen in Rabenh. Krypt. Flora **3**: 582–588.

CURRENT LITERATURE.

BOOK REVIEWS.

Experimental morphology.[1]

It is with pleasure that we welcome a text-book in this comparatively new field of biology. While embryology is investigating the problem, *how* adult forms are produced, it is the new school of physiological morphology that deals with the question "*why* does an organism develop as it does?" And it is with this question of such great importance to physiologists and morphologists alike that this work occupies itself.

This first part is devoted to those processes which are characteristic of all living protoplasm, and it is quite needless to say that both plants and animals are included in its range.

One of the characteristics of the book is the stress laid upon quantitative measurements of agents and effects. No better opening sentences could have been selected than those of Jaeger and Jevon:

> Die morphologische Betrachtung setzt also eine genaue chemische und physikalische Kenntniss 1. des betreffenden Körper selbst und 2. aller der bei seiner Entstehung auf ihn einwirkenden Stoffe und Körper voraus.

"There can be little doubt, indeed, that every science as it progresses will become gradually more and more quantitative."

The book is divided into nine chapters. The first deals with the action of chemical agents upon protoplasm, and it is here especially that the great value of exact quantitative work becomes apparent. The third section, devoted to chemotaxis (chematropism), is doubtless one of the most attractive in the whole work. Pfeffer's classical experiments are quite fully related.

From the second to the eighth chapters the author treats of the effects of (1) moisture, (2) density of medium, (3) molar agents, (4) gravity, (5) electricity, (6) light, and (7) heat. In general it may be said that a fair historical review is given of the literature on these subjects. In a few cases, it is our opinion that better illustrative experiments could have been chosen. In some cases too much space is given to the Protista, to the exclusion of the Metazoa. This is especially so in the section on stereotaxis (stereotropism), where only a bare reference is made to the stereotaxis of multicellular forms

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[1] DAVENPORT, C. B., Experimental morphology, Part I. 8vo. pp. xiv + 280 New York: The Macmillan Company. $2.60.

Doubtful and perplexing examples of Protista and spermatozoa are presented, while such clear and striking examples as are afforded by the experiments of Dr. Loeb on the moth Amphipyra are not mentioned. The same objection holds with still greater force in regard to the chapter on geotaxis.

Another thing which we regret is that in a text-book of biology, which evidently bases all biological phenomena upon the chemistry and physics of the organism and its environment, such metaphysical terms as photophil, photophob, lovers of dark, etc., are used. The same applies to the terms so frequently used, "adaptation," "advantageous to the organism." If by adaptation is meant no more than if we were to say that the photographic plate is adapted to the action of the light, the term is misleading. If, however, by such terms more is understood, it brings physiology back to the realm of metaphysics, a result contrary to the general tendency of the book.

We are glad the author, even at the risk of becoming wearisome to the ordinary reader, goes quite extensively into the physics and chemistry of such subjects as light and solutions. The fuller description of methods will certainly be highly appreciated by the student. Indeed, seeing how much in biological investigation depends upon methods, we could almost wish the author had been still more elaborate in this respect.

In general, the subject matter is well presented. Relatively much space is given to the facts and little to conflicting theories. The style is clear and concise. The bibliography will be of great use to the investigating student. The spirit of the first part is such that we shall look with impatience for the other three parts on growth, cell-division, and differentiation. The author has certainly done a great service to the student of biology in the careful collecting of the numerous researches in the field of experimental morphology, and we doubt not that the book will prove of immense value as a text, and as a stimulus to further and more thorough investigation.—W. D. ZOETHOUT.

Vegetables under glass.

THE last issue of the "Gardencraft Series"[2] deals with the forcing of vegetables. It is precisely what its subtitle indicates: a manual of the cultivation of vegetables in glass houses. It gives explicit directions for the construction and management of forcing houses, enumerates the vegetables commonly grown or capable of being grown in such houses, and gives detailed instructions for the growing of each. These instructions are based upon results actually worked out by the author and others. While the author is convinced that the forcing of vegetables is "bound to open up great possibilities for the future," he is conservative in advising beginners to undertake the work, and carefully points out the difficulties that must be surmounted. Unquestionably this is the most comprehensive and valuable book that has thus far been published on the subject, and no one who is engaged in the forcing of vegetables, or who contemplates engaging in it, can afford to be without it.

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[2] BAILEY, L. H., The forcing book: a manual of the cultivation of vegetables in glass houses. 12mo., pp. xiv+266, figs. 88. New York: The Macmillan Company, 1897.

A considerable part of the subject matter of this book has already been published by the author or his assistants through the bulletins of Cornell University, and the author has quoted rather freely from other sources. But the parts are so well adjusted, and so well supplemented by the author's hitherto unpublished experiences and observations that the somewhat fragmentary structure of the book does not appear, and the freshness, clearness and grace that characterize all of Professor Bailey's writings abound throughout. If his sentences are sometimes less polished than we might expect from so learned a writer, the intensity of their expression and the fertility of the thoughts they convey always render them most pleasant and profitable reading.—E. S. GROFF.

Monographia Cactacearum.[3]

Botanists and gardeners everywhere will greet with pleasure Professor Schumann's *Monographia Cactacearum*, the first part of which has just appeared. An inspection of this justifies the assertion that expectation will not be disappointed; for the work promises to satisfy in a large measure the long felt needs not only of botanists, but also of cactus growers generally, amateur and professional. The author has studied the group during the greater part of eight years, visiting the principal botanic gardens of Europe, constantly examining growing plants in all stages, and bringing together in Berlin an unsurpassed collection of living and dried material. Certainly the Botanic Garden in Berlin, with its cactus prestige of nearly a century, furnishes rare opportunities for such a comprehensive study as Professor Schumann has undertaken, for in this, as in no other family of plants, the element of culture tradition enters as an exceedingly important factor. It happens in numerous species of all genera that existing individuals can with absolute certainty be referred back through years of culture to their originals, constituting a thread of identity which would otherwise long since have been quite obliterated. It has thus been possible in the present work to rescue many of the older species from oblivion, not, however, without that ever present element of uncertainty that arises from the instability of vegetative characters so prevalent in the family. Furthermore, as guiding spirit in the Berlin Gesellschaft der Kakteenfreunde, and as editor of the *Monatschrift für Kakteenkunde*, the author has long been in close communication with an army of collectors and cactus growers, the importance of whose cooperation in this knotty group can not be overestimated. The work will appear in ten fascicles at intervals of two months, constituting when complete a handsome royal octavo volume of 600 pages or more.

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[3] SCHUMANN, KARL.—Gesamtbeschreibung der Kakteen (monographia Cactacearum). Part I, large 8vo, with 100 text cuts. Neudamm: J. Neumann. *M.* 2.

With the exception of a rather comprehensive introduction devoted to general morphology and geographic distribution, the work is purely systematic, with short, excellent, clear cut descriptions. In his chapter on distribution the author brings up the old but interesting question of the origin of old world forms. The original home of *Opuntia vulgaris* remains unsettled. The widespread occurrence of Rhipsalis in tropical Africa is logically accounted for through the instrumentality of bird migration, the mucilaginous juice of the berry suggesting the possibility of an occasional seed clinging to feathers for a considerable period. The "author's index" presents a novel feature in the form of personal or biographical comment, furnishing to cactus lovers an interesting and useful compendium of information.

The family is subdivided as follows:

I. Subfamily CEREOIDEÆ.

Tribe 1. *Echinocacteæ.*—Cereus, Pilocereus, Cephalocereus, Phyllocactus, Epiphyllum, Echinopsis, Echinocereus, Echinocactus, Melocactus, Leuchtenbergia.

Tribe 2. *Mamillariæ.*—Mamillaria, Pelecyphora, Aniocarpus.

Tribe 3. *Rhipsalideæ.*—Pfeiffera, Hariota, Rhipsalis.

II. Subfamily OPUNTIOIDEÆ.

Tribe 4. *Opuntiæ.*—Opuntia, Nopalea, Pterocactus.

III. Subfamily PEIRESKIOIDEÆ.

Tribe 5. *Peireskieæ.*--Peireskia.

It will be noticed from the above that twenty genera are recognized, of which one is new. *Cephalocereus* (Pfeiff.) em. K. Sch. has for its typical representative our Mexican "old man cactus," *Cephalocereus senilis*. *Pterocactus* K. Sch., from Argentina, is a most remarkable representative of the Opuntioideæ, being distinguished not only from the other genera of its tribe, but from all other Cactaceæ, by its circumscissile dehiscent capsule and broadly winged seed.

Further particulars, so far as they are of general systematic interest, will be mentioned from time to time in this journal as the successive parts appear. —E. B. ULINE.

Septal nectaries.

Though numerous studies have been made of the nectar glands of the ovarian septa of monocotyledons, first described in 1855 by Brongniart, Schniewand-Thies[4] has submitted them to a comparative examination as to their morphology and the behavior of their cell contents during the period of greatest activity.

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[4] J. SCHNIEWAND-THIES.—Beiträge zur Kenntnis der Septalnectarien. Pp. 87. *pl. 12.* Gustav Fischer: Jena, 1897. *M.* 15.

From the simple external nectary of *Tofieldia palustris*, in which the secretion is effected by the epidermal cells of the entire outer wall of the ovary, appearing first as a subcuticular accumulation, and the slightly more specialized nectary of *T. calyculata*, where the similarly subcuticular secretion is limited to the epidermal cells of the septal grooves, a gradually increasing complexity is traced to the Bromeliaceæ, which have complex branched glands deeply seated in the tissues of the ovary — though they really represent gaps between the partially fused carpels, so that they are likewise lined by epidermal cells, which, however, have a well-developed subjacent secreting parenchyma — and the conclusion is reached that the simplest glands belong to genera or species which stand lowest in the systematic classification.

The results of the morphological study are summarized in the tabulation of septal nectaries under the following seven groups, in which the increasing size and complexity of the glands is accompanied by a corresponding development of the vascular system of the ovarian walls:

A. *Ovary superior.*

1. Simple external nectaries (Tofieldia).
2. Double nectaries, in which each outer nectariferous groove passes at top into a septal fissure which is commonly more active (Scilla, Yucca).
3. Inner nectaries, having the general structure of the preceding, but the inner clefts only active (Asparagus, Allium).

B. *Ovary partly inferior.*

4. Mostly double nectaries, with the inner cleft increased in surface by being folded, and the upper part sometimes reduced to a mere duct (Phormium, Hemerocallis).

C. *Ovary inferior.*

5. Double nectaries, the inner clefts more or less complicated (Beschorneria, Crocus).
6. Inner nectaries, opening at top of the ovary (Agave), or in ducts near its middle (Bilbergia).

D. *Ovary superior or partly inferior.*

7. Nectary consisting of three outer and three inner septal fissures, and three inner clefts pertaining to the sutures of the several carpels, into the cavities of which and the stylar canal they run, above (Pitcairnia, Dyckia, Vriesea).

The general conclusion is reached that the cell contents of the secreting tissues are actively concerned in (1) the storage of carbohydrates and albuminoids which are subsequently used in the formation of nectar; (2) supplying the necessary water; (3) converting the accumulated materials into nectar; (4) the spontaneous passage of the nectar outwards.

As a rule, to which Hemerocallis offers exceptions, the nuclei of the secreting tissues become disorganized and dissolve earlier than those of the adjacent parenchyma, though at first richer in chromatin. In most active nectaries they are said to have a predilection for blue stain, though in some cases they have been found, either at first or throughout, to take the red stain by preference.

The behavior of the chromatin and nucleolar contents of the nuclei during activity of the gland appears to differ greatly in different plants, but in general one or both diminishes noticeably. Nuclei becomes deformed and lobed or even fragmented, send out pseudopodia like prolongations to the ends of which plasma threads become attached, or the nuclear membrane is absorbed and the nuclear material diffuses in the cytoplasm, which itself gradually diminishes or even disappears; meantime the starch accumulation in the vicinity of the nectary is used up, though some reserve starch is often brought into this tissue later.

In the main the descriptions of structure are clearly written, and the plates are all excellently drawn and reproduced. If any fault were to be found with the paper it would be that the student of a given genus or species is confused by the division of the work and plates into separate sections, each of which contains partial studies of a number of species, which, in the absence of a general index, cannot well be united by the reader.—W. T.

Physiological plant anatomy.[5]

THE first edition of this book appeared in 1884. In its preface the author explains that his endeavor was to make plain the connection between anatomical structure and physiological performance. In the preface of the present edition the author states that the subject has made such progress that the book must be much enlarged. The plan and manner of arrangement has not been materially changed, about 150 pages and 95 illustrations having been added. The same number of chapters is retained, although an entirely new one on the apparatus for special functions is added; the two on normal and abnormal growth in thickness being here combined. An introduction and a discussion of the plant cell is added to the first chapter. In short, while still holding to the same object as before, the book is enlarged and improved in every chapter. The author says of the new edition:

> It is no longer the elements of physiological anatomy, but a veritable text-book; not a hand book or cyclopedia, because a great deal of relevant matter has been omitted. All the research that serves only to broaden our knowledge is omitted, and only that used which has deepened it.

One of the most helpful additions to the new edition is the introduction, where the author states clearly and fully the meaning of the expression "physiological plant anatomy." In doing this he gives a new significance to the word anatomy, a meaning which is necessary to the very conception of physiological anatomy. He defines the scope of morphology as including the outer and inner structure. The inner structure includes histology and anatomy; as far as the inner structure is confined to the elements of the separate tissues, it is histology; when we go farther and consider the tissues in relation to their position and arrangement in the plant, it is anatomy. This brings out clearly the principle upon which physiological anatomy is based, that is, the connection between function and form, when form is limited to certain tissues and combinations of tissues inside the plant. These tissues and combinations of tissues are therefore to be considered as organs in the real sense of the term, and not simply as the component parts of the plant.

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[5] HABERLANDT, DR. G.—Physiologische Pflanzenanatomie. Wilhelm Engelmann: Leipzig. 1896.

Another prominent feature of this book is the copious notes or references at the end of each chapter. Here are discussed in detail those points of the text which may be considered debatable, and all the authorities on such questions are cited. For example, Strasburger maintains that the anatomical-physiological idea is not a part of morphology, but must be considered as belonging to physiology. He expressly states that morphology is based upon phylogenetic principles only and has nothing whatever to do with the idea of function. This Haberlandt considers a too narrow conception of morphology. He makes phylogenetic morphology only a branch of the whole subject, saying that as we characterize a tissue or tissue system, like the palisade tissue or the skeleton system, by its morphological qualities as well as by its physiological performance, we must admit that such tissues and systems may be treated from a morphological standpoint.

He further claims that this method of classification of tissues is the broadest of all and the only one based on purely scientific principles, because it considers the plant as an individual organism consisting of elementary organs by virtue of which it is enabled to carry on a series of life processes.

Other methods of classification may be used, but they must be carried out in a manner consistent with the principles upon which they are founded. But a method purely didactic, which aims only to form a convenient basis for a general view of the different tissues cannot be called scientific. These clearly expressed statements of the two opposing views concerning the nature and scope of morphology are of special interest at the present time, as they serve to define the principles held by physiological anatomists, as contrasted with modern morphologists. For example, Strasburger maintains that phylogeny is the only basis of morphology, and that the only way to determine morphological characteristics is to show that one form has been derived from another. But Haberlandt claims that we do find certain morphological characteristics in any cell complex which is sufficiently unified to be called an organ, or to have a separate individual function. Therefore, we are justified in disregarding the notion of phylogeny, and in constructing a set of tissue systems from purely ontogenetic considerations, and of these we may choose only those pertaining to function. On the other hand, we are also justified in classifying the tissue systems according to phylogenetic principles, but this is not the most logical method.

These statements are also of importance in showing the advance actually made in this subject during the past twelve years. Twelve years ago botanists were unwilling to relinquish the idea of the unity of the so-called fibrovascular bundle, and still regarded the views of Schwendener on the primary function of the thick walled cells of the monocotyledons with a certain degree of suspicion. All this is changed, and in all our recent text-books in which this subject is treated, the complete bundle is spoken of as consisting of stereom and mestom, and the elements of the former are described as mechanical or supporting cells. Thus the truth of the first principle upon which physiological anatomy was founded is fully recognized and admitted by all.

The first chapter of Haberlandt's book contains a full and modern treatment of the typical plant cell, a description of plant tissue, and a classification of tissue systems according to the anatomical physiological principle.

The second chapter treats of tissues in general and the relation of meristems to lasting tissues, and here we find a departure from the interpretation usually given to the developmental processes of the apical region. In all higher plants, at a greater or less distance from the apex, the uniform primary meristem cells differentiate into several distinct building tissues or meristems. These at first show no difference of outer or inner meristems, except the mere topographical one and the histological difference between strand-tissue and ground parenchyma. Regarding the function of the lasting tissue which is to be developed they give no hint. These primary meristems are not necessarily connected with any special kind of apical growth as regards their origin or arrangement. They may be found in plants having only a single apical cell, also in those with several initial cells. That is, three distinct meristems, which Haberlandt names protoderm, procambium, and ground tissue, may be found in the apical regions of plants from the moss upward. He states that since the time of Hanstein's investigations many plants have been examined which do not show a separation into the three distinct meristems, plerome, periblem and dermatogen, and that the manner of apical growth in the phanerogams is subject to too great variation to allow the selection of a single type as furnishing a general law.

The succeeding chapters treat of the eight tissue systems. The plan in each case is to explain first the advantages which the plant derives from the system under consideration, and then to give a clear and full description of its elements and their relations to other parts of the plant. A short paragraph in each chapter is devoted to the system as it occurs in the thallophytes, and its developmental history forms the concluding paragraphs of each chapter, except in the case of the absorption system where such an exposition is unnecessary. The chapters on the absorption and assimilation systems are considerably enlarged, the former by a paragraph on the absorption of water by the hairs of foliage leaves. The chapter on the conducting system is also much enlarged, the author giving an exposition of the theories of water conduction and explaining the present status of our knowledge of this difficult and perplexing subject. Another section of the same chapter illustrates the author's idea of the dependence of form upon function, that is, that organs are called into existence by some special need of the plant. In this connection he gives an hypothesis concerning the probable manner of development of the different kinds of bundles.

The chapter on apparatus for special purposes contains a description of the various means of plant motion. The passive organs are the flying and swimming tissues which are fully described and illustrated. The active tissues are described as hygroscopic and living, the latter including those through which movements are caused by outer stimuli. The tissues supposed to receive stimuli and those designed only for their conduction are fully treated.

In style the book is exceedingly clear and attractive, and the principles upon which its method of treatment rests are now admitted by all. It is questioned by some, however, whether this classification of tissue systems should be substituted for the older and simpler one which is now in general use. The objections are that it presupposes at least a partial knowledge of the tissues, and that it is too extended to find a place in a text-book on general botany. Both of these objections have more weight perhaps in this country than in Germany. It is also true that the simpler method is far more practical for students of pharmacy and medicine, and for any others who wish only a general view of this branch of botany. In view of these considerations it would seem wiser for us, at least, to precede such a view as Haberlandt presents by a general view based simply upon didactic principles.—EMILY L. GREGORY.

NOTES FOR STUDENTS.

THE ACTION of the yeast cell during alcoholic fermentation has always been a difficult matter for the physiologist to explain. Most writers for the last twenty-five years have considered fermentation a specific form of protoplasmic activity, possessed by certain species of lower plants in a highly developed form. The view of Traube (1858) and of Hoppe-Seyler, ascribing fermentative action to an albuminoid compound secreted by the yeast cell, allied in its nature to the enzymes, has never found favor with botanists. Nägeli in his carefully considered theory of fermentation (1879) pointed out very important differences between the behavior of so-called organized and unorganized ferments, and laid particular stress upon the fact that it had been found impossible to separate any substance from yeast or other organized ferment that would produce an alcoholic fermentation independent of living protoplasm. Sachs has also elaborated the same opinion. The problem has been further complicated by the assumption by Pfeffer, Wiesner, Noll, and others, that alcoholic fermentation is identical with intramolecular breathing, and therefore through a series of gradations with normal breathing.

A discovery which promises to be of great importance in this connection was announced by Dr. Eduard Buchner[6] of Tübingen in a preliminary communication to the German Chemical Society on January 11. He has separated a nitrogenous compound from yeast which produces a vigorous and characteristic alcoholic fermentation without the presence of yeast or bacteria cells, *i. e.*, independent of living protoplasm.

The method pursued in separating the ferment was as follows. A thousand grams of pure compressed yeast were mixed with an equal weight of quartz sand and 250 grams of diatomaceous earth and the whole ground together until the mass became moist and plastic. This was mixed with 100^{cc} of water and then subjected to a pressure of four to five hundred atmospheres in a hydraulic press. By this means about 300^{cc} of liquid was secured. The remaining cake was broken up and mixed with 100^{cc} of water, and being pressed as before yielded about 150^{cc} additional liquid, which was added to the first. The liquid, being somewhat turbid, was shaken up with 4 grams of diatomaceous earth and filtered through paper several times.

A clear liquid was thus obtained having a specific gravity at 17° C. of 1.0416 and yielding a large percentage of dry substance. By microscopic and bacteriological tests it was found to be absolutely free from yeast cells, and almost or quite free from all other germs.

When this extract is added to an equal amount of a strong solution of either cane, grape, or invert sugar, a vigorous fermentation starts up after a quarter of an hour to an hour and continues for days. There is no action, however, with lactose or mannite, substances which do not ferment with living yeast. The fermentation is not prevented by the presence of chloroform. The liquid lost its fermentative action in a low temperature after five days, but in presence of cane sugar kept it for two weeks under otherwise the same conditions. When heated to 50 C. a flocculent precipitate forms and the power of fermentation is lost. When precipitated with alcohol and dried over sulfuric acid it became inactive. The active principle appears to be incapable of dialysis, but its exact behavior in this regard has not yet been determined.

The author believes that he has demonstrated that alcoholic fermentation is a chemical change, carried on independent of living protoplasm by means of a characteristic proteid substance, for which he proposes the name *zymase*.

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[6] Buchner, Eduard: Alkoholische Gärung ohne Hefezellen. Ber. d. deutsch. chem. Ges. 30: 117-124. 1897.

This substance appears to have characters sufficiently different from the enzyms to entitle it to be placed in a distinct class of compounds. It seems probable, although not yet proven, that the yeast cell excretes the zymase into the surrounding liquid, and that the fermentation takes place outside of, and not within the living cell.

From the results so far obtained it appears safe to conclude that alcoholic fermentation is brought about by a non-living substance allied to the enzyms, and that the process is entirely distinct from both intramolecular and normal breathing. Further research along this line will undoubtedly bring to light other important discoveries.—J. C. A.

CAPTAIN HENRY D'ALBERTIS in 1893 equipped the "Corsaro," and on June 3 sailed from Genoa, following as closely as possible the course of Columbus in his voyage of discovery, and on July 20 reached the island of Guanahani,[7] called also San Salvador or Watling. The algæ collected were given to Professor Anthony Piccone for study, whose paper[8] is a useful contribution to phycogeography. Captain d'Albertis collected *Dasycladus occidentalis* Harv. and *Acetabularia crenulata* Lamour, in the interior salt lake of Guanahani. On July 21 he collected in the Atlantic, fifty miles off the mouth of the Delaware river, floating specimens of the following species: *Sargassum bacciferum* (Turn.) Ag., *S. vulgare* Ag., *S. filipendula* Ag., *Fucus vesiculosus* L., *Ascophyllum nodosum* (L.) Le Jol., *Jania rubens* (L.) Lamour (on the frond of *S. filipendula*). *Ascophyllum nodosum* was also collected in the Gulf Stream 150 miles S. E. of the Grand Banks of Newfoundland, and at 42° 6′ N. lat. and 46° 30′ W. long. Between New York and the Azores, d'Albertis collected *Sargassum Hystrix* J. Ag., *S. bacciferum* (Turn.) Ag., *S. cymosum* Ag., *Fucus vesiculosus* L., and *Ascophyllum nodosum* (L.) Le Jol.—DE TONI.

DR. G. KRAUS differs from the usually accepted view that calcium oxalate is a waste product of plant metabolism, and contends that it frequently plays the rôle of a reserve material.[9]

Finding by quantitative chemical analyses that the calcium oxalate present in roots of *Rumex obtusifolius* undergoes no noticeable diminution during the formation of its tall shoots in ordinary soil under usual conditions, he transplanted roots in early spring into pots containing in one case pure sand, and in the other case sand mixed with an abundance of calcium salts, and grew the plants in darkness to create the maximum demand on their reserves.

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[7] That is, the true Guanahani, the first American island discovered by Columbus, not to be confounded with the false Guanahani or Cat, which is between Watling and Eleuthera.

[8] PICCONE, A.—Nota su alcune Alghe della Campagna del "Corsaro" in America. Atti della Società ligustica di Scienze naturali e geografiche 7: —. 1896. [fasc. 4.] Genoa.

[9] DR. GREGOR KRAUS, Flora 83: 54–73. 1897.

After two months analysis showed a marked loss of the calcium oxalate in the roots cultivated in pure sand, and but little decrease in the roots grown in the sand containing calcium. He concludes the oxalate here was drawn on to supply a demand for calcium.

The conduct of calcium oxalate in stems and branches was also investigated. In this connection analyses of barks with reference to the distribution of oxalate are of interest. The bark from trunks and branches of several trees gave uniformly a largely increasing amount of oxalate as one passes inward toward the cambium, the extremes in the oak being 4.96 per cent. in the outer cortex in the autumn, and 11.03 per cent. in the inner parts.

Analyses made at different times in the growing season showed that during the development of the buds the amount of calcium oxalate in the bark undergoes a marked decrease. The loss resulting from spring development was found to range between 12 and 42 per cent. of the amount present in the winter. This is accepted as evidence that calcium oxalate is made use of during the season of spring activity.

The solubility of calcium oxalate in various plant acids was tested and found to be considerable in concentrations varying from 0.1 to 0.001 per cent. Crystals examined after treatment presented a corroded appearance.

The author regards the water stream passing upward from the roots through the stem as the dissolving medium, and sees in the large calcium content often observed in the sap of trees a confirmation of this view.—RODNEY H. TRUE.

THE ECOLOGICAL RELATIONS of the underground systems of plants have been too little regarded, in spite of the fact that many of the most significant adaptations are of a subterranean nature. Rimbach's former studies[10] on underground stems and their methods of becoming deeply placed have been supplemented by a more comprehensive recent study.[11] In the meantime Areschoug has written a paper upon the same subject.[12] Areschoug has introduced the term "geophilous" plants, meaning those plants whose shoots persist in the soil, the antithetical term "aerophilous" denoting such plants as have aerial shoots. The geophyte condition is an adaptation against climatic extremes; annuals die when the dry or cold season advances, trees and shrubs protect themselves by lignification, while most perennial herbs seek protection by ceasing aerial activities and remaining essentially dormant within the soil. Areschoug divides the geophytes into tufted perennials, rosette perennials, perennials with much branched base, bulb perennials, and rhizome perennials. The tufted and rosette types are not true geophytes, but are transitional forms. The third type sends up an aerial shoot the first season; this shoot dies down to the surface, and the next year branches from the base at several points; ultimately the basal parts are quite complex. Bulbous and rhizomatous plants represent the typical geophytes. Monocotyls have worked out better geophilous adaptations than have dicotyls. One of the important functions of geophilous plants is to store up a reserve food supply in the roots, stems or leaves. Plants with horizontal axes wander from year to year, more commonly in a straight line, though sometimes in a circle (orchids). Many plants become more deeply placed year by year. This burying is effected (1) by a downward growth of the stem, in which case the old stem parts are left behind; (2) by root contraction, in which case the plant is pulled down into the soil as a whole; or (3) by the intercalary growth of the petiole. Plants seem to have the power of self regulation, burying rapidly if put in shallow soil, slowly if put in deep soil. Rimbach considers this to be a matter of reciprocal action between leaves and roots; deep stems use up more energy in getting to the light and have a shorter period for assimilation, hence less energy can be expended in the work of burying deeper.—H. C. C.

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[10] Biologie der Pflanzen mit unterirdischem Sprosse. Ber. d. deutsch. bot. Ges. **13**: 141–155. 1895. Tieflage unterirdisch ausdauernder Pflanzen. Ber. d. deutsch. Bot. Ges. **14**: 164–168. 1896.

[11] Lebensweise der geophilen Pflanzen. Ber. d. deutsch. bot. Ges. **15**: 92–100. 1897.

[12] Beiträge zur Biologie der geophilen Pflanzen. Acta Reg. Soc. Phys. Lund. T. 6. 1896. See Bot. Cent. **68**: 20–24. ——.

THE ANNUAL REPORTS of a few of the Experiment Stations contain valuable botanical matter in addition to that issued through the bulletins. L. R. Jones, in the Vermont Report for 1895 (pp. 66–115), writes on potato blights, potato scab, oat smut, onion mildew, making and use of Bordeaux mixture, with many valuable original observations and deductions. W. C. Sturgis, in Connecticut Report for 1895 (pp. 166-190), writes on potato scab, onion smut, plum leaf curl, and notes on other diseases. S. M. Bain, in the Tennessee Report for 1896 (pp. 16–19), gives notes upon plant diseases observed within the state. B. D. Halsted, in the New Jersey Report for 1895 (pp. 247–361), and also in the Report for 1896 (pp. 287–429), records observations upon a large number of plant diseases, the fungi causing them, and on trials of fungicides, together with some other matters of botanical interest.—J. C. A.

MR. G. N. CALKINS finds tetrad formation and a reduction division in two ferns, *Pteris tremula* and *Adiantum cuneatum*.[13] The mitosis of the spore mother cells was studied, and the author finds that the chromosomes in both divisions behave in general as has been described by Häcker, Rückert, and vom Rath, for the maturation divisions in a number of animals. The reduction in the number of the chromosomes before the first division is a "pseudoreduction," and in the second division we have probably only a transverse and no longitudinal splitting of the chromosomes.

[13] Bulletin of Torrey Bot. Club **24**. 1897.

The author uses largely the terminology of spermatogenesis in animals to describe the well known stages in spore development. The desirability of this innovation is perhaps questionable. We have come to use, to be sure, a common nomenclature for many stages in the vegetative mitosis of both plant and animal cells, but until the significance of the processes in the sporange and the ovary and testis are better understood it is perhaps best not to insist too much on the value of apparent analogies. Spore development and reduction of the chromatin are undoubtedly associated with alternation of generations in plants, and until it is settled whether a similar relation exists in animals a separate terminology is desirable. The author expresses much surprise that "such obvious structures as tetrads should have been hitherto overlooked in the plant reproductive cells." This is, however, merely a question of name, since he does not dispute the accuracy of the figures for the lilies as given by Farmer, Strasburger, and others. The term is certainly not very applicable to the figures in lilies, where the contraction of the chromosomes in the prophases does not go so far as to reduce them to almost spherical shape as in the ferns. This fact probably makes the lilies more favorable for the study of reduction than are the ferns. The existence of "tetrads" can hardly be regarded as settling the question of a reduction division in Weismann's sense. Mottier, in the latest paper on the lilies, admits that two interpretations of the figures are possible, and that the occurrence of a longitudinal splitting of the chromosomes in the second division is not absolutely excluded.—R. A. H.

THOSE INTERESTED in the physiology of the fungi will find record of a large number of experiments by Alfred Lendner upon some Mucorini and conidial forms of Ascomycetes in *Annales des Sciences Naturelles* (Bot.) VIII. 3: 1–64. 1897. His investigations were addressed to the question of the combined influences of light and the substratum upon the development of the fungi which were selected haphazard. The results have proved very variable not only in the two groups, but even in the same species, so that no general conclusions have been reached.—C. R. B.

H. TITTMANN has studied the formation and regeneration of periderm, epidermis, wax-coverings and cuticle in various plants.[14] His researches were conducted at Leipzig, under the direction of Professor Dr. Pfeffer.

The effect of increased pressure upon the formation of the periderm was investigated by means of gypsum bands surrounding young twigs of various woody dicots. This produces a retardation of cork development, but does not suppress it, as Newcombe had already shown,[15] the cork cells departing only slightly in number and form from those produced under normal conditions.

[14] Jarhrbücher f. wiss Botanik 30: 116–154. 1897.

[15] BOT. GAZ. 19: 149. 1894.

The regeneration of the periderm is not prevented by the checking of secondary thickening. In the open twigs from which the periderm was sliced replaced it from the cortical parenchyma, though the number of cells was not so great as the normal, except in *Sambucus nigra* in which they were more numerous. In a moist atmosphere the exposed cortical cells grew into long tubes, forming a callus, from which the periderm was produced.

No regeneration of epidermis was observed, but its removal was followed by the formation of cork or of callus and then cork.

Wax coverings were replaced in only three plants observed, *Ricinus communis*, *Rubus biflorus*, and *Macleya cordata*, and then only when the plants were still in vigorous growth. Several sedums and echeverias examined did not secrete wax after it had been removed. Light produced no effect upon this process, and moist air diminished, but did not entirely prevent it.

The removal of the cuticle could only be accomplished upon leaves with a very thick outer epidermal wall, such as the agaves and aloes possess. When sliced off it was reformed, even in the moist air, in which, however, it was thinner. Filaments of *Cladophora glomerata* were cut into pieces (which do not grow longer) and cultivated for four weeks. The transverse walls, now exposed, became covered with a cuticle. Typical water plants, like *Ceratophyllum demersum* and *Elodea Canadensis*, could not thicken the cuticle on exposure to air, so that it was impossible to cultivate them under new conditions. Even the submersed leaves of *Nuphar luteum* and *N. advena* could not live as floating leaves. On the contrary the water leaves of *Sagittaria sagittifolia* and *Hippuris vulgaris*, upon exposure to air, lived and thickened the cuticle strongly. Some land plants (*Mentha aquatica*, *Polygonum Hydropiper* and *Lysimachia nummularia*) easily adapted themselves to a submersed life, forming then only a very delicate cuticle as a result of diminished transpiration.

The delicate membrane covering the cells bordering upon the large intercellular spaces of many water plants (and some land plants also), designated as cuticle by Frank, reacts to increased transpiration, becoming partly lifted up from the cell walls into blisters or considerably thickened. Whatever its nature it is certainly not equivalent to the true cuticle.—C. R. B.

NEWS.

Mr. Alfred W. Bennett, Lecturer on Botany at St. Thomas' Hospital, London, has been appointed editor of the *Journal of the Royal Microscopical Society*, to succeed Professor F. J. Bell.

As we are going to press the death of Dr. Julius Sachs, the eminent physiologist, is announced, having occurred at Würzburg, May 29. The GAZETTE hopes soon to publish a biographical sketch, prepared by Dr. Fritz Noll.

Dr. J. N. Rose has gone to Mexico for a summer of collecting. He left Washington for Guaymas the last of May, where he will spend some time with Dr. Palmer. Later at Mazatlan he will meet Mr. E. W. Nelson, and together they will cross the mountains into Durango and Jalisco.

Sunstroke is the name given to a physiological condition of the grapevines observed in 1895 in California, and known in France as *folletage*. The leaves wither and drop off in hot weather, without apparant preliminary symptoms. The cause appears to be connected with the supply or movement of water in the plant, but no exact study has yet been devoted to the subject.

Dr. Emily Gregory, Professor of Botany in Barnard College, died at her home in New York City, April 21. The name of Miss Gregory is a familiar one to botanists, both as author and teacher, and the announcement of her death, at the very height of her activity, occasions widespread sorrow. The GAZETTE is glad to be able to publish one of her last contributions, a review of Haberlandt's important *Physiologische Pflanzen-Anatomie.*

At the meeting of the Academy of Science of St. Louis, held on the evening of May 3, 1897, Mr. H. von Schrenk spoke of the respiration of plants, with special reference to the modification of those growing with their roots submerged in water. The lecture was illustrated by a demonstration of the liberation of carbon dioxide in respiration from the roots of an ordinary flowering plant and freshly gathered fungi, and the more usual aerenchyma structures were made clear by the use of lantern slides.

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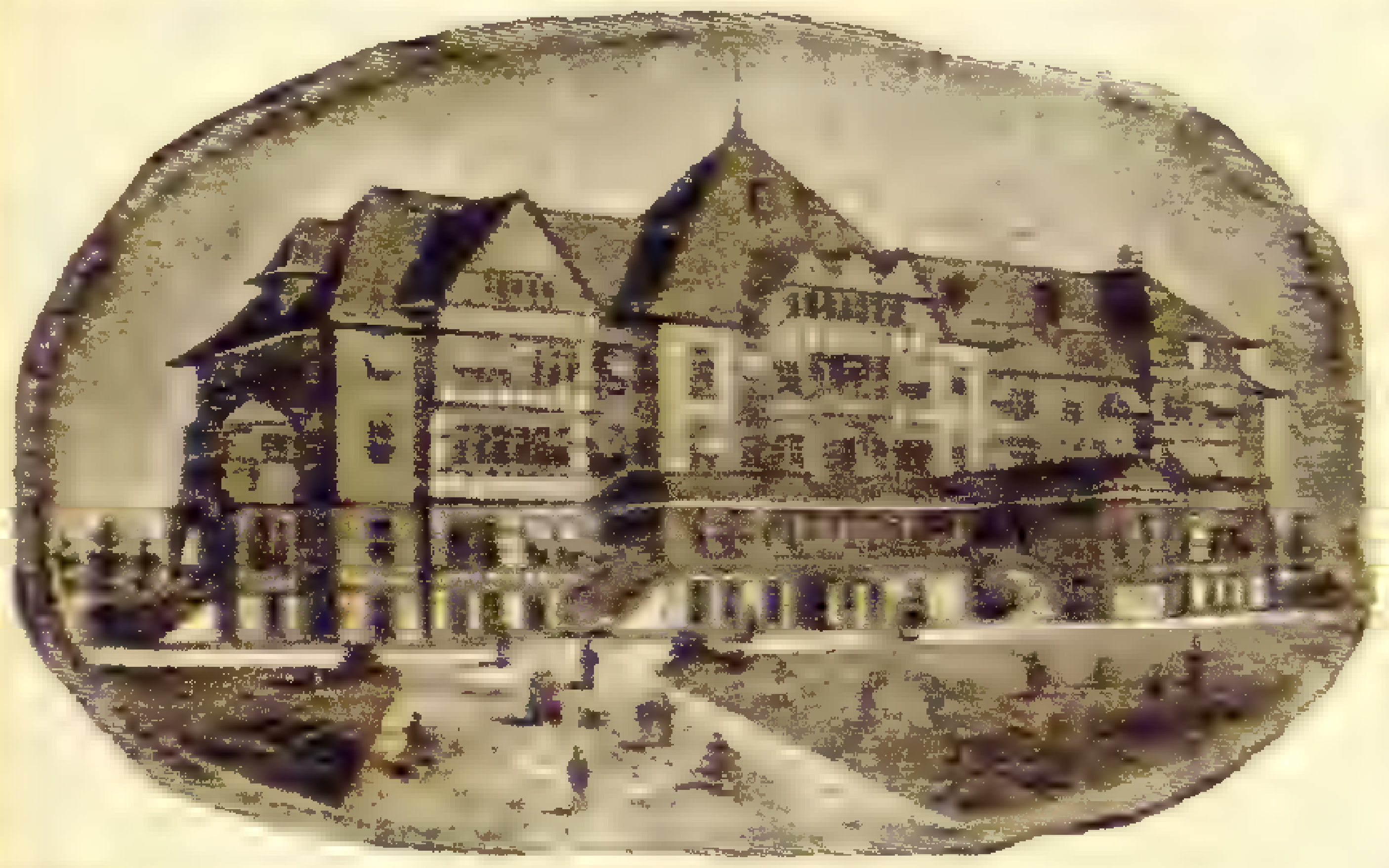

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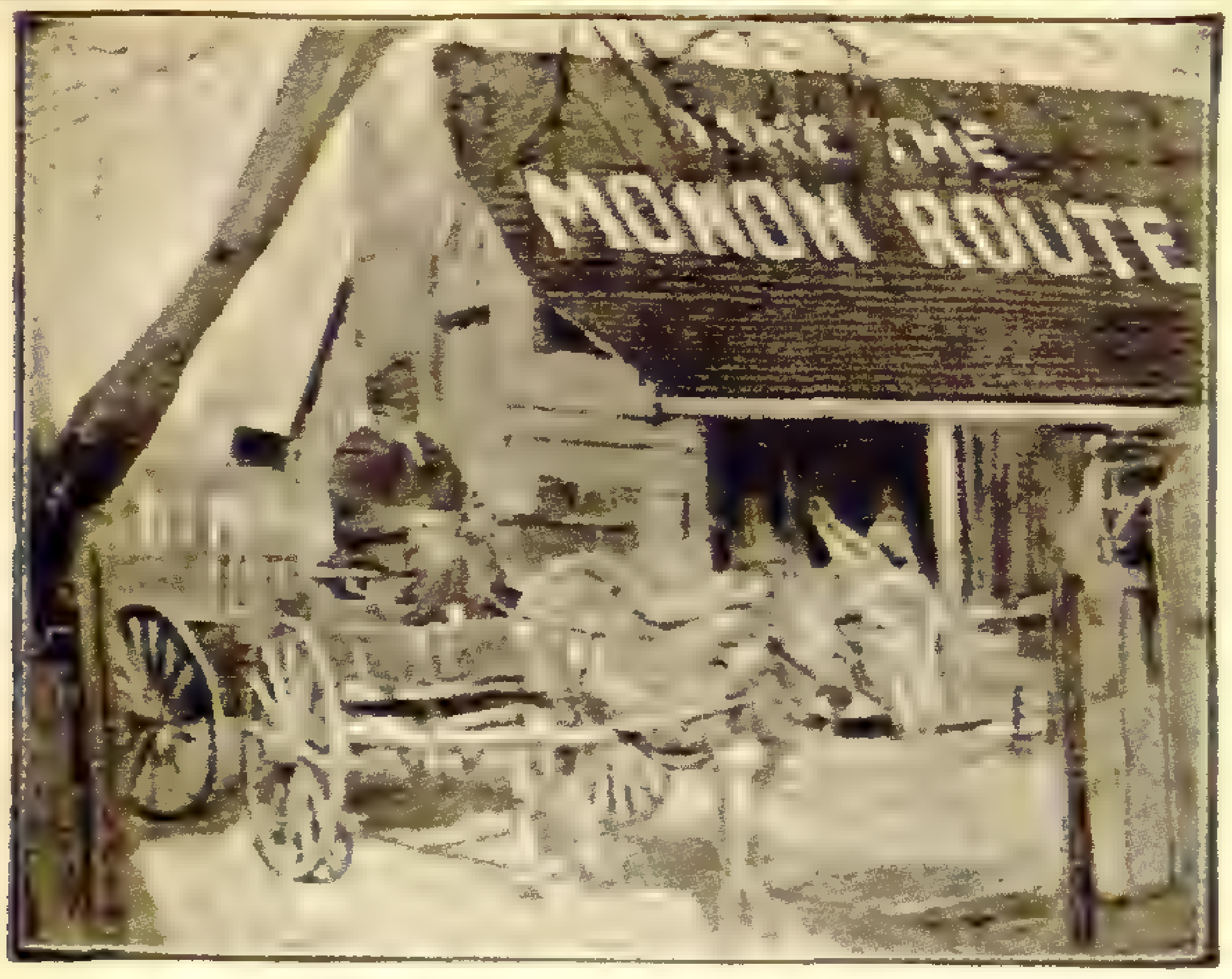

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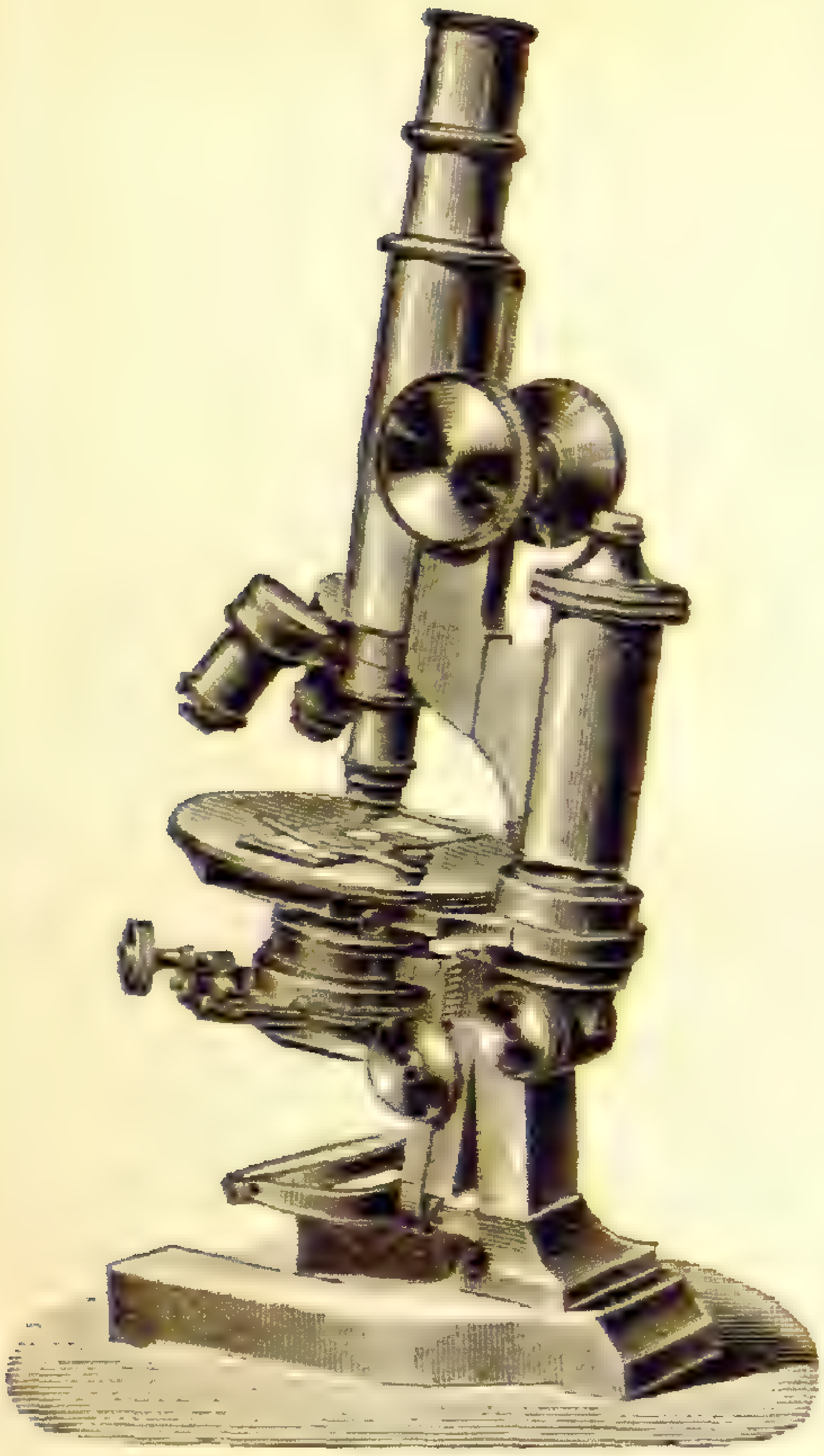

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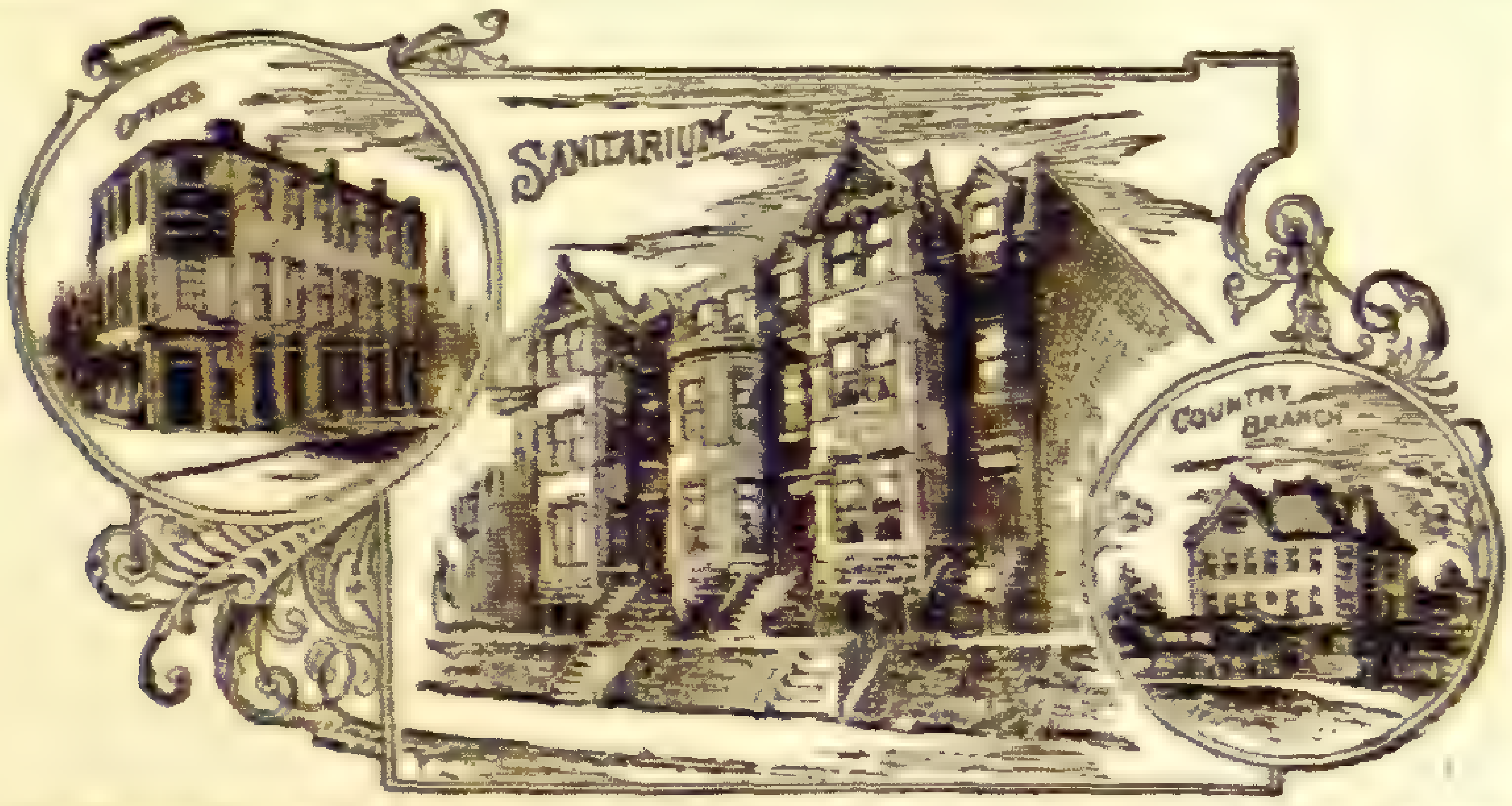

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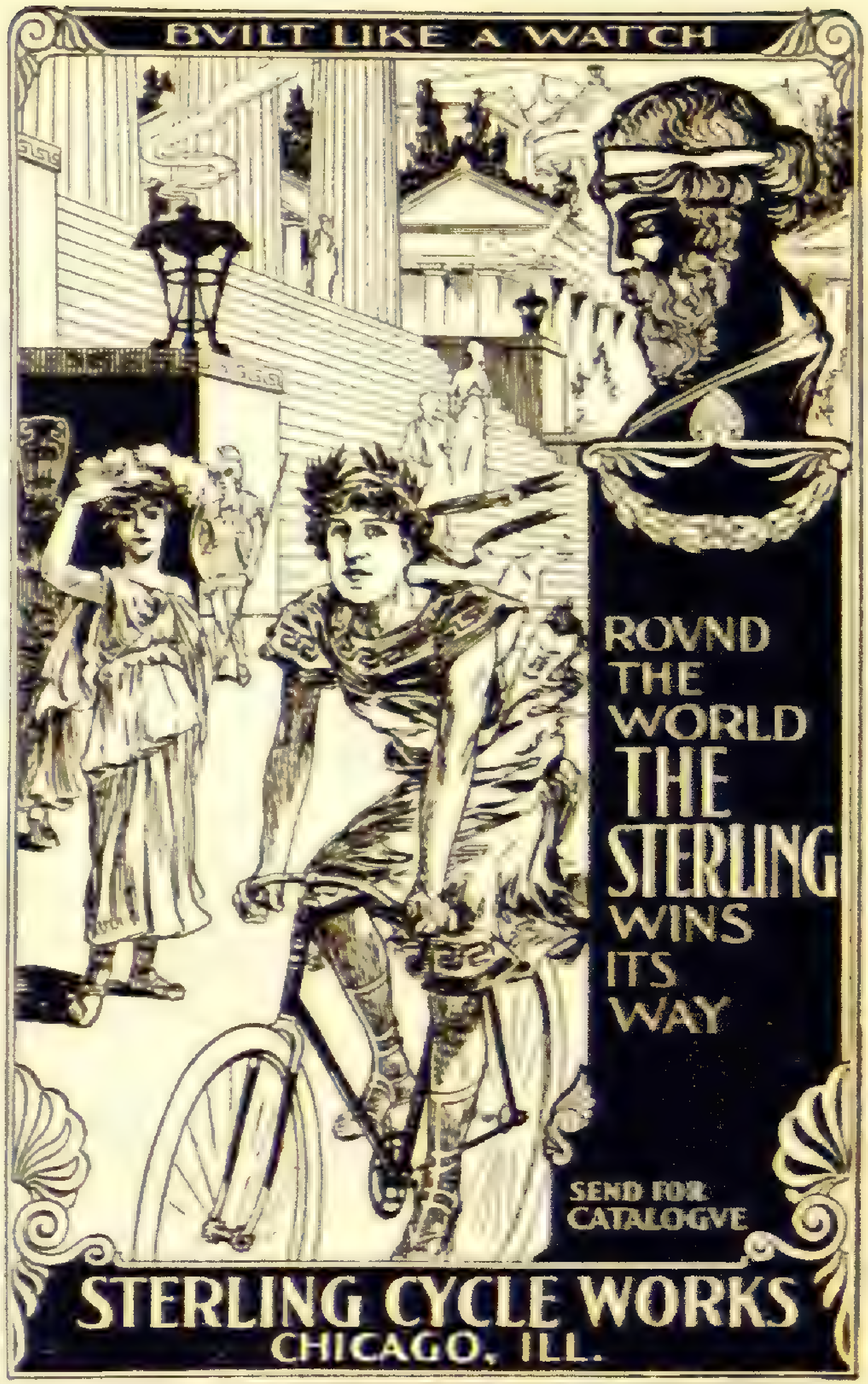

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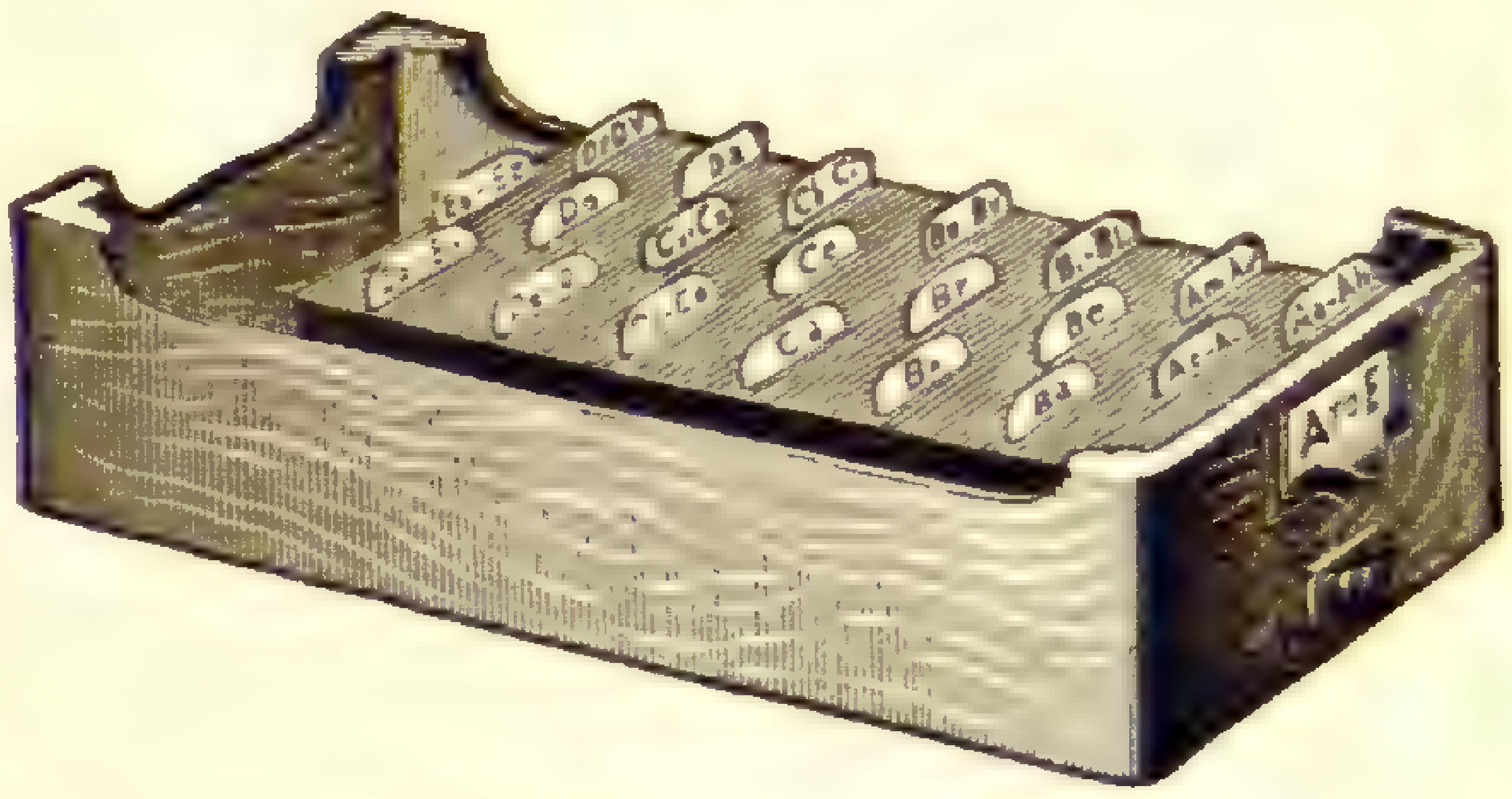

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